(12)

AD_____

REPORT NO T7-87

NUTRITIONAL STATUS AND PHYSICAL AND MENTAL PERFORMANCE OF SPECIAL OPERATIONS SOLDIERS CONSUMING THE RATION, LIGHTWEIGHT, OR THE MEAL, READY-TO-EAT MILITARY FIELD RATION DURING A 30-DAY FIELD TRAINING EXERCISE

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

MARCH 1987

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

SECURITY CLASSIFICATION OF THIS PAGE

AD-A177 553

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION N/A	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distributions unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) T7-87	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Research Institute of Environmental Medicine 6b. OFFICE SYMBOL (If applicable) SGRD-UE-MN	7a. NAME OF MONITORING ORGANIZATION U.S. Army Medical Research Development Command
6c. ADDRESS (City, State, and ZIP Code) Natick, MA 01760-5007	7b. ADDRESS (City, State, and ZIP Code) Fort Detrick, MD 21701-5012
8a. NAME OF FUNDING/SPONSORING ORGANIZATION USARIEM 8b. OFFICE SYMBOL (If applicable) SGRD-UE-MN	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Natick, MA 01760-5007	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 6.2 / PROJECT NO. 3M2637 63D819 / TASK NO. AI / WORK UNIT ACCESSION NO. 071

11. TITLE (Include Security Classification) Nutritional Status and Physical and Mental Performance of Special Operations Soldiers Consuming the Ration, Lightweight or the Meal, Ready-to-Eat Military Field Rations during a 30-Day Field Training Exercise

12. PERSONAL AUTHOR(S)
Askew, E. W., Munro, I., Sharp, M. A., Siegel, S., Popper R. Rose, M., etal

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM Sept 86 TO Oct 86	87 March 23	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Calorie restriction, work performance, nutrient intake, mental performance, body composition, field study, Meal, Ready-to-Eat, Ration, Lightweight-30

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A 2000 kcal lightweight ration (RLW-30) was tested as the sole source of food for 30 continuous days during a Special Forces field training exercise (FTX) in September and October, 1986 at Camp Ethan Allen, VT. Eighteen Special Forces soldiers were assigned to the RLW-30 group and another 18 were assigned to a calorie adequate control ration (MRE VI). Both groups of soldiers performed similar missions at the same location but were physically separated from each other. A battery of physical and psychological tests was conducted before, during and after the 30-day FTX. Food and water intakes were recorded daily and nutritional and hydration status were evaluated. Medical examinations were conducted before, during and after the FTX. Soldiers consuming the RLW-30 ration lost an average 11.4 lbs/man (6.3% of original body weight) compared to 4.0 lbs/man (2.2% of original body weight) for the MRE group. The weight loss for the MRE group was provided by body fat loss. The weight loss for the RLW-30 group came from a combination of body fat and lean body mass. Aerobic capacity decreased 10.2% for the MRE group and 14.8% for the RLW-30 group. Isokinetic

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

muscle strength and endurance did not decrease in the MRE group but decreased 3.1 and 7.9% respectively in the RLW-30 group. There were no differences between groups in handgrip strength or PT test performance. Vigilance, mood, morale and cognitive ability were maintained to a similar degree in both groups, but the RLW-30 group completed less voluntary cognitive work and reported significantly more symptoms (weakness, dizziness/lightheadedness, and symptoms related to visual, motor, and cognitive disturbances).

Medical examinations did not reveal serious medical problems and there was no evidence of direct ill effects from the ration. Some members of the RLW-30 group noted trace urinary protein and microscopic hematuria by the dipstick method but the follow-up evaluation revealed normal urines. One test subject was removed from the RLW-30 group after 21 days for medical problems that were not directly attributable to the ration. Seventeen out of the 18 test subjects were able to complete the 30 day FTX in both groups. Nutrient intakes were adequate to meet Military Dietary Allowances for both groups except for energy and protein in the RLW-30 group. These macronutrients were intentionally reduced in the ration to meet size and weight constraints and reduce the water burden of the ration. The hydration status of both groups was good. The RLW-30 group consumed 4.4 liters of water/man/day compared to 3.4 liter/man/day for the MRE group. The RLW-30 is a compact ration that is palatable and easy to use by the soldier in the field, provided an adequate supply of water is available. It supported physical and mental performance reasonably well in a low stress temperate environment. The results of this study indicate that the RLW-30 ration, if used as a sole source of food for 30 days, can be expected to cause some uncomfortable physical symptoms and a small to moderate decrement in physical performance capacity that should be considered in mission planning.

HUMAN RESEARCH and DISCLAIMER STATEMENTS

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

Report No T7-87

Nutritional Status and Physical and Mental Performance of Special Operations Soldiers Consuming the Ration, Lightweight or the Meal, Ready-to-Eat Military Field Ration During a 30 Day Field Training Exercise

LTC E. W. Askew, Ph.D., Military Nutrition Division, USARIEM
I. Munro, M.A., Health and Performance Division, USARIEM
M. A. Sharp, M.S., Exercise Physiology Division, USARIEM
S. Siegel, Ph.D., Behavioral Sciences Division, SATD, NRDEC
R. Popper, Ph.D., Behavioral Sciences Division, SATD, NRDEC
MAJ M. S. Rose, Ph.D., Military Nutrition Division, USARIEM
R. W. Hoyt, Ph.D., Altitude Research Division, USARIEM
MAJ J. W. Martin, M.D., Surgeon, 10th SFG(A)
MAJ K. Reynolds, M.D., Exercise Physiology Division, USARIEM
H. R. Lieberman, Ph.D., Mass. Institute of Technology
D. Engell, Ph.D., Behavioral Sciences Division, SATD, NRDEC
C.P. Shaw, B.S., Product Development Branch, FED, NRDEC

March 1987

U. S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

ACKNOWLEDGMENTS

The authors wish to acknowledge the technical assistance of SSG David Moore, SGT Anthony Marshall, Joan Buchbinder, Edward Roche, Joseph Williams, Thomas Dugan, Mark Polin, Julie Pocost, Lisa Hodgess, SP4 Jack Stoskopf, Pam Reich, SSG Calvin Witt, SSG James O'Connell, SP4 William S. Scott, SGT Ronald Manikowski, SGT Jose Castro, SSG Donald Ross, Robert Rando, Paula Poole, and Heather Dragsbaek. MAJ Scott Ekdahl provided medical consultation in the initial phase of this study. The cooperation and support of LTC Eric Ekhardt (3rd BN Commander), MAJ Hayward Florer (XO, 3rd BN), MAJ Theodore Mickel (S3, 3rd BN), MAJ James Torpey (OIC, Test Site), SFC Strickland (Operations NCO) and SFC Dennis Hanson (Chief Medical NCO) from the 10th SFG(A) Ft. Devens, MA in planning the operational aspects of this study is acknowledged and appreciated. Finally, we would like to acknowledge the spirit and fortitude of the 36 volunteer soldiers from the 2nd and 3rd BN, 10th SFG (A) Ft. Devens, MA. Their spirit of cooperation and genuine interest in the rations and the testing procedures greatly facilitated the testing aspects of this study. The honesty, candor, spirit and discipline of this group of soldiers was evident throughout the full 30 days of this study.

FOREWORD

The data for this report were collected by investigators from the U. S. Army Research Institute of Environmental Medicine (USARIEM) and Natick Research Development and Engineering Center (NRDEC) during the 30 day development and operational test (DT/OT II) of the Ration, Lightweight - 30 Days. The field aspects of this test took place during the months of September and October 1986 at Camp Ethan Allen Training Center, Jerico, VT. Pre and post testing was conducted at Ft. Devens, MA and at the U. S. Army Research Institute of Environmental Medicine, Natick, MA. This report encompasses nutrient intakes, physical and mental performance and medical aspects of the test. Nutritional assessment encompassing blood and urine analyses will be reported in a subsequent report. John F. Kennedy Specialized Warfare Center (JFKSWC) and the Training and Doctrine Command (TRADOC) assisted in developing the test issues and pass/fail criteria. The 10^{th} Special Forces Group (A) performed the user evaluation of the RLW-30 ration. USARIEM was designated by JFKSWC to be the medical tester and evaluator. Human factors and DT aspects of this test were evaluated by the Science and Advanced Technology Laboratory, NRDEC. Testing and Evaluation Command (TECOM), Aberdeen, MD was the overall independent evaluator for this test.

TABLE OF CONTENTS

ABSTRACT

A 2000 kcal lightweight ration (RLW-30) was tested as the sole source of food for 30 continuous days during a Special Forces field training exercise (FTX) in September and October, 1986 at Camp Ethan Allen, VT. Eighteen Special Forces soldiers were assigned to the RLW-30 group and another 18 were assigned to a calorie adequate control ration (MRE VI). Both groups of soldiers performed similar missions at the same location but were physically separated from each other. A battery of physical and psychological tests was conducted before, during and after the 30 day FTX. Food and water intakes were recorded daily and nutritional and hydration status were evaluated. Medical examinations were conducted before, during and after the FTX. Soldiers consuming the RLW-30 ration lost an average 11.4 lbs/man (6.3% of original body weight) compared to 4.0 lbs/man (2.2% of original body weight) for the MRE group. The weight loss for the MRE group was provided by body fat loss. The weight loss for the RLW-30 group came from a combination of body fat and lean body mass. Aerobic capacity decreased 10.2% for the MRE group and 14.8% for the RLW-30 group. Isokinetic muscle strength and endurance did not decrease in the MRE group but decreased 3.1 and 7.9% respectively in the RLW-30 group. There were no differences between groups in handgrip strength or PT test performance. Vigilance, mood, morale and cognitive ability were maintained to a similar degree in both groups, but the RLW-30 group completed less voluntary cognitive work and reported significantly more symptoms (weakness, dizziness/lightheadedness, and symptoms related to visual, motor, and cognitive disturbances). Medical examinations did not reveal serious medical problems and there

was no evidence of direct ill effects from the ration. Some members of the RLW-30 group noted trace urinary protein and microscopic hematuria by the dipstick method but follow-up evaluation by urinalysis revealed normal urines. One test subject was removed from the RLW-30 group after 21 days for medical problems that were not directly attributable to the ration. Seventeen out of 18 test subjects were able to complete the 30 day FTX in both groups. Nutrient intakes were adequate to meet Military Dietary Allowances for both groups except for energy and protein in the RLW-30 group. These macronutrients were intentionally reduced in the ration to meet size and weight constraints and reduce the water burden of the ration. The hydration status of both groups was good. The RLW-30 group consumed 4.4 liters of water/man/day compared to 3.4 liters/man/day for the MRE group. The RLW-30 is a compact ration that is palatable and easy to use by the soldier in the field, provided an adequate supply of water is available. It supported physical and mental performance reasonably well in a low stress temperate environment. The results of this study indicate that the RLW-30 ration, if used as a sole source of food for 30 days, can be expected to cause some uncomfortable physical symptoms and a small to moderate decrement in physical performance capacity that should be considered in mission planning.

INTRODUCTION

Special operation soldiers (Special Forces, Rangers, Scouts) must be capable of sustaining themselves deep behind enemy lines for extended periods of time. Foraging is sometimes a possibility, but cannot be counted upon to sustain the soldier conducting rapid covert missions or engaged in combat. Special Operations Mission Area Analysis has established a need for a flexibly-packaged, lightweight, compact ration to sustain the operational effectiveness of special operations soldiers. JFK Special Warfare Center, Ft. Bragg, NC, requested that the U. S. Army Troop Support Command's Natick Research Development and Engineering Center, Natick, MA develop a lightweight ration (Ration, Lightweight-30 days) to be issued for individual transport and consumption when required by operational conditions (tactical situations such as initial land/air assault, deep reconnaissance, combat patrols and surveillance and evasion operations). The ration must be packaged in a chemical and biological agent-proof packet weighing no more than one pound and having a volume of less than 45 cubic inches. This ration provides approximately 2000 kcal/man/day and is vitamin and mineral fortified to meet the Nutritional Standards for Operational Rations (NSOR) found in AR 40-25 (1). Energy, protein, and sodium content were established according to Office of the Surgeon General (OTSG) guidelines. These rations are intended to be eaten for time periods of up to 30 days as the sole source of food. Ration components include dehydrated entree bars, cereal bars, beverage bars, bread alternate bars, beef jerky, dairy bars, dessert bars and fruit bars. All the components can be eaten dry; some can also be rehydrated. Nutrient composition and menu descriptions for the Ration, Lightweight-30 Days (RLW-30) and the standard Meal, Ready-to-Eat (MRE VI) rations can be found in Appendix 1.

Two limited field evaluations of 7 and 12 days each have been previously conducted at Ft. Bliss, TX and Ft. Chaffee, AR with prototypes of this ration (2). The results of these two tests demonstrated that the ration was palatable and resulted in moderate weight losses of 5.4 ± 0.6 lbs/man over a 12 day time period. These results suggested that a 170 lb soldier engaged in light to moderate activity for 30 days might be expected to lose 13.6 lbs body weight (8% weight loss). The exact magnitude of the weight loss might be expected to vary for the individual soldier depending upon his body weight, the climate, his clothing, the load he is carrying, the terrain over which he is moving and the length of time he is engaged in the various activities. It can be predicted that a 2000 kcal/day ration should be adequate to maintain body weight in most sedentary activities, but may incur a 1000 – 2000 kcal/day energy deficit with heavy physical activity. AR 40-25 recommends 3600 kcal/day as adequate for moderate physical activity. Assuming a 1600 kcal/day energy deficit for 30 days, and assuming the weight loss incurred comes from the body fat component (3500 kcal/lb of fat), a 30 day weight loss of approximately 14 lbs can be predicted. This calculated weight loss is similar to the 13.6 lb weight loss projected from the 12 day Ft. Chaffee test of the RLW-30 ration.

Given the weight and volume constraints imposed upon ration designers, it is not feasible to provide more than 2000 kcal/man/day in a 1 lb ration. The remainder of the energy requirement must be provided from the adipose tissue reserves of the soldier. A 155 lb soldier with a typical amount of body fat would have 15% or approximately 23 lbs of fat, 15 lbs of which would be "sparable" for energy. The remaining 8 lbs of fat is essential for nerve sheath insulation, structural integrity of membranes and cushioning of vital organs. Theoretically, it would be feasible for the average soldier to lose up to 15 lbs of body fat over a 30 day time

period in response to a chronic energy deficit. The central issue then becomes one of performance. What is the effect of weight losses of this magnitude on physical and mental performance? This question is only partially answered in the medical literature.

The effects of long term semi-starvation have been documented (3). Food restriction for 7 - 14 day time periods has been studied extensively (4-9), however little information is available concerning the effect of moderate energy deficiency on operational efficiency during longer time periods. Taylor et al. (10) have concluded that when enough calories, vitamins and NaCl are provided to prevent ketosis, dehydration and hypoglycemia under the conditions of moderate energy output, performance capacity is well maintained up to a weight loss of 10% of the initial body weight. Rapid deterioration of maximal oxygen uptake may occur when body weight loss progresses past 10% (10). Crowdy et al. (8) have concluded that 12 days of energy restriction (2000 kcal/day energy deficit) did not impair soldier physical capacity or the performance of vigilance, arithmetic, coding or shooting skills.

In summary, the literature suggests that soldiers consuming a 2000 kcal/man/day ration for 30 days engaged in light to moderate work in a temperate environment may not experience excessive decreases in performance capability and may be expected to lose 8 - 10% of their body weight, assuming ample availability of water. The exact operational conditions for which the RLW-30 ration was designed are not directly duplicated by any study published in the literature. The present study was necessary to provide a medical evaluation of the feasibility of feeding the RLW-30 ration to special operations soldiers as the sole source of food for 30 consecutive days.

REFERENCES

1. Nutrition allowances, standards and education. Army Regulation 40–25. Headquarters, Department of the Army, The Navy, and the Air Force, Washington, D.C., 15 May 1985.

2. Siegel, S.F., P.M. Poole, E.W. Askew, M.A. Kinney, C. Shaw, J. Aylward, and S. Hunter. Twelve day field test of Ration Lightweight, 30 day at Fort Chaffee, Arkansas. Natick Research Development and Engineering Center Technical Report (in preparation) 1987.

3. Keys, A., J. Brozek, A. Henschel, O. Michelsen, and H.L. Taylor. The biology of human starvation. Minneapolis, MN., Univ. of Minnesota Press, 1950.

4. Consolazio, C.F., L.O. Matoush, and C.W. Harris. Nutritional and acceptability evaluation of high caloric density foods under combat patrol conditions. U.S. Army Medical Research and Nutrition Laboratory Report No. 288, 1965.

5. Consolazio, C.F., H.L. Johnson, R.A. Nelson, R. Dowdy, H.J. Krzywicki, T.A. Daws, L.K. Lowry, P.P. Waring, W.K. Calhoun, B.W. Schewenneker, and J.E. Canham. The relationship of diet to the performance of the combat soldier. Minimal calorie intake during combat patrols in a hot humid environment. Presidio of San Francisco, CA. Letterman Army Institute of Research. Report No. 76, 1979.

6. Johnson, H.L., L.O. Matoush, C.F. Consolazio, and H.J. Krzywicki. The effects of caloric restriction upon performance. Fed. Proceedings 26:474, 1967.

7. McMurray, R.G., V. Ben–Ezra, W. Forsythe, and A.T. Smith. Responses of endurance–trained subjects to caloric deficits induced by diet or exercise. Med. Sci. Sports Exercise 17:574–579, 1985.

8. Crowdy, J.P., M.F. Haisman, and H. McGavock. Combat nutrition, The effects of a restricted diet on the performance of hard and prolonged physical work. Army personnel Research Establishment, Farnborough, Hants. Report No. 2/71, 1971.

9. Crowdy, J.P., C.F. Consolazio, A.L. Forbes, M.F. Haisman, and D.E. Worsley. The metabolic effects of a restricted food intake on men working in a tropic environment. Human Nutrition: Applied Nutrition 36A:325–344, 1982.

10. Taylor, A.L., E.R. Buskirk, J. Brozek, J.T. Anderson, and F. Grande. Performance capacity and effects of caloric restriction with hard physical work on young men. J. Appl. Physiol. 10:421–429, 1957.

TEST ISSUES

Paragraph 5 of the letter requirement for the Ration, Lightweight – 30 Days states that the RLW–30 ration must meet 3 essential medical/nutritional characteristics.* These characteristics and their component operational test issues and pass fail criteria** are as follows:

1.0 "The RLW–30 must meet daily minimum caloric and nutritional requirements for a 30 day ration (one food packet per day) as established by the Surgeon General (OTSG)."

1.1 Caloric and Nutritional Consumption

1.1.1 Will soldiers consuming the RLW–30 ration for extended time periods (30 days) receive adequate amounts of nutrients to meet the Military Recommended Dietary Allowances (MRDA) for operational rations as shown in Table 2–1 of AR 40–25 and/or guidance provided by the Surgeon General?

1.1.1a Pass/Fail: Mean 30 day intakes for vitamins and minerals must meet 90% of the Military Recommended Dietary Allowances for selected nutrients shown in Table 2–1 of AR 40–25.

1.1.1b Pass/Fail: Sodium intakes should fall between 3000–3800 mg Na^+/day.

1.1.1c Pass/Fail: Energy, carbohydrate and protein intakes should be at least 90% of the amount provided daily in the ration.

---

* Letter Requirement (LR) for the Ration, Lightweight, 30–Day (RLW–30) HQ, U.S. Army Training and Doctrine Command, Ft. Monroe, VA, (ATCD–SE) dated 13 August 1985.

** These test issues and pass/fail criteria were arrived at during joint working group meetings between the proponent (TRADOC), the ration developers (FED/NRDEC), the user organization (JFKSWC), and the independent evaluators (TECOM, USARIEM, SATD/NRDEC).

2.0 "The RLW-30 must not cause unacceptable diminished soldier performance or adverse effects on health when consumed for extended periods."

2.1 Body Weight

2.1.1 Will the RLW-30 maintain body weight loss within acceptable limits over a 30 day time period?

2.1.1a Pass/Fail: Mean body weight loss <10% of initial body weight.

2.1.2 Will the weight loss observed be provided predominantly by the body fat component, not lean body mass or total body water?

2.1.2a Pass/Fail: Decreases in Body Fat should account for >90% of the weight loss observed.

2.1.3 Is the weight loss observed consistent with the caloric intake and estimated energy expenditure and hydration status?

2.1.3a Pass/Fail: Investigative.

2.2 Blood Constituents

2.2.1 Will the RLW-30 ration maintain blood vitamin, mineral, protein, and lipid status within ranges recognized as indicative of normal nutritional status?

2.2.1a Pass/Fail: Blood chemistries must not fall lower than the medium risk level for standard values indicative of nutritional deficiencies.

2.2.1b Pass/Fail: Urine ketone bodies (acetoacetone) must not test greater than 80 mg/dl during time periods after week 1.

2.3 Symptoms

2.3.1 Will the RLW-30 ration support good general health as evidenced by medical evaluation (physical exam, physical symptoms)?

2.3.1a Pass/Fail: Results of physical exam equivalent pre vs. post 30 day test.

2.3.1b Pass/Fail: Results of the Environmental Symptoms Questionnaire should be similar between both groups.

2.3.1c Pass/Fail: Incidence of gastrointestinal related complaints should be similar between both groups.

2.4 Body Fluid Status

2.4.1 Will soldiers fed the RLW-30 ration drink sufficient fluids to maintain hydration status?

2.4.1a Pass/Fail: Group mean urine specific gravities must not test >1.030 during time periods after week 1.

2.5 Physical Performance

2.5.1 Does the RLW-30 ration support muscle strength, endurance and aerobic capacity to at least 90% of the control (calorically adequate) group?

2.5.1a Pass/Fail: Measurements of physical performance for the RLW-30 group should be at least 90% of the calorically adequate control group.

2.6 Mental Performance

2.6.1 Does the RLW-30 ration permit the maintenance of cognition and vigilance with no decrement in performance?

2.6.1a Pass/Fail: No significant decrease in these tests over 30 day time period.

2.6.2 Are mood and morale maintained to the same degree in the RLW-30 and control group?

2.6.2a Pass/Fail: Mood and morale maintained in the RLW-30 group at least as well as in the control group.

3.0 "The RLW-30 ration must be sufficiently palatable to ensure consumption and of sufficient variety to achieve widest acceptability by all personnel for periods up to 30 consecutive days."

3.1 Ration Acceptability and Human Factors
(This is a developmental test issue.)

3.1.1 Is the RLW-30 ration sufficiently palatable and acceptable to permit extended utilization (30 days) of this ration?

3.1.1a Pass/Fail: Greater than 90% of the RLW-30 ration should be consumed.

TEST METHODS

Test Subjects

This test was conducted under a human use protocol approved by the USARIEM and USAMRDC/OTSG Human Use Review Committees. The test subjects were provided by the 2nd and 3rd Battalions (BN), 10th SFG(A), Ft. Devens, MA. The test subjects were briefed on the purpose of the test and the risks involved. All test subjects participated in these studies after giving their free and informed volunteer consent. Test subjects were monitored weekly by a physician and understood that they could withdraw from the study at any time. Thirty six test subjects began the study and 34 completed the study. Two individuals were removed from the test for medical reasons. The test subjects were experienced soldiers averaging 27 years of age, 70 inches height, 174 lbs body weight and 16% body fat. All were under 39 years of age.

Operational Scenario

Two special task force (ODA) teams of 18 men each were established prior to the test. Each team consisted of a 12 man Special Forces Operational Detachment Alpha (SFODA) team augmented by a 6 man communication/electronic warfare Special Operation Team Alpha (SOTA). The 12 man SFODA team had the responsibility of providing security and logistical support to the SOTA team while engaged in surveillance and electronic warfare missions. A series of 4 identical missions, each lasting one week were conducted by each of the two 18 man teams. These missions involved reconnaissance, surveillance and electronic warfare. A central base camp was established in the field at Camp Ethan Allen Training Center, VT. This base camp was occupied by the command and control elements of the 3rd BN

that was directing and controlling the field training exercise (FTX). Two GP–Medium tents were erected and maintained at this site for weekly medical testing procedures. The teams received their missions at the base camp and were infiltrated and exfiltrated weekly by the support staff. One day per week was devoted to medical monitoring/testing and refitting for the next mission. The test subjects lived out of their packs and were self–sustaining for food and shelter for the entire time (25 days) that they were in the field. Five of the 30 days of the test were spent in garrison (pre and post testing). The test was conducted in late September and October under temperate conditions. Temperatures averaged between 40–51^{o}F during this time period although freezing temperatures and snow were encountered at times during the test. The daily environmental conditions and operational activity summaries can be found in Appendix 2.

The two 18 man teams were designated as an experimental team (RLW–30) and a control team (MRE). The RLW–30 team was issued one case of 30 rations/man (30 lbs) which they packed in their rucksacks. The MRE team was issued 21 meals of MRE rations/man/week (21 lbs). Space and weight limitations in their rucksacks precluded them from taking more than one week's supply of MRE's at a time, due to the bulky and heavy nature of this ration. The MRE group was permitted to break the food packets down into components and take or leave individual food items as they desired. This was normal operational procedure for these soldiers utilizing MRE rations for one week missions of this nature. The RLW–30 group were not permitted to break down the individual RLW–30 rations into components since they were unfamiliar with this type of ration and the requirement for the ration specifies that 30 days supply of food must be able to be carried. They were instructed to eat the ration by menu and not trade individual food components. The

MRE group was permitted to trade food items within their group. These two groups were physically separated during their time in the field and were not permitted to trade food items between ration groups. No other food items were permitted during this test. The test site was remote without access to other food sources. Foraging was not permitted.

The area of operations of the test site was mixed deciduous and coniferous forest without established trails. The terrain was hilly and ranged from sea level to approximately 4000 feet elevation. Ground water was abundant during this FTX. Both groups started with rucksack weights of approximately 100 lbs. Rucksack weights taken at the midpoint of the study prior to the start of week 3 were 76.7 ± 3.1 and 73.2 ± 1.5 lbs for the MRE and RLW-30 groups, respectively. Pack weights remained relatively equal throughout the test except toward the end when the cumulative consumption of the 30 days supply of the RLW-30 ration caused the RLW-30 pack weights to be up to 25 lbs lighter than the MRE group.

Experimental Design

The experimental design is shown in Table 1. Testing was conducted pre-FTX, at weekly intervals, and post-FTX according to Table 2. The experimental design was one of 2-factors (Rations) with repeated measures (Time). Pre and post testing was done at Ft. Devens and USARIEM. Field testing was done at the FTX base camp at Camp Ethan Allen, VT. The 30 day test period began 2 days prior to deploying to the field during lock down at Ft. Devens. The next 25 days were spent at Camp Ethan Allen and the final 3 days were spent in lock down at Ft. Devens and at USARIEM.

General Methodology

The soldiers were made available to the investigators at the field test site for 1/2 day each week for weekly testing. A portion of the data was recorded daily by the soldiers themselves (urine chemistries, food intake, vigilance tests, self initiated behavior logs, etc.).

Table 1. Test Design

Test Group	N	Ration	kcal/day[2]	Duration (days)
Control	18	MRE VI	4023	30
Experimental	18	RLW-30	2000	30

[1] Both groups were physically separated but simultaneously engaged in the same FTX performing similar missions over similar terrain.

[2] Maximum kcal available or offered/man/day. The MRE VI ration used in this study contained 8 oz entrees in 7 out of 12 menus. Three beverage powder packets (135 kcal/packet) were added to each days ration. With the exception of the 7 larger entrees and the beverage powder, the food components of this ration were similar to MRE I-V.

Table 2. Test points during RLW-30 30 day study

	Body Weight	Body Fat	Endurance	Strength	Blood	Urine Specific Gravity	Food Intake	Physical Exams	Physical Symptoms	Human Factors	Cognition Vigilance Mood Morale
Pre-experiment	x	x	x	x	x	x		x	x	x	x
Week 1	x			x		x	x		x	x	x
Week 2	x			x	x	x	x		x	x	x
Week 3	x			x		x	x		x	x	x
Post-experiment	x	x	x	x	x	x		x	x	x	x

Body weights were taken at 0600 following an overnight fast. The soldiers were weighed wearing the same uniform (T-shirts, fatigue trousers with pockets empty, and in stocking feet) at each weighing. Weights were taken in duplicate on two calibrated digital electronic battery powered balances accurate to ±0.1 lb (SECA Model 770). Scales were calibrated prior to each use using 100 lb calibration weights. Urine samples tested for specific gravity and ketones were conducted on first void in the morning collections following an overnight fast. Weekly urine samples were analyzed for specific gravity with a refractometer (American Optical Model 10400A) whereas daily urine specific gravities and ketones were measured by the test subjects utilizing urine dipsticks (N-multistix, Ames Division, Miles Laboratories) and recorded in a log book. Refractometer urine specific gravities were accurate to ±0.001 units whereas dipstick specific gravities were only accurate to ±0.005 units. Blood samples for hemoglobin and hematocrit were drawn on day 1, day 15 and day 30 at 0600 following an overnight fast. Blood samples for the blood chemistries accompanying the physical exam were drawn following an overnight fast during the 2 weeks prior to the FTX and on day 26 near the end of the FTX.

Format for Sub-Report Sections

This report is a multidisciplinary effort of several investigators each investigating a specific technical aspect of the study. The results are grouped and presented according to research topic(s) in nine sub-reports. Each sub-report has a methods, results, and discussion section. References, tables, and figures are presented within each sub-report. Specific testing methodology and procedures are described in each section. This decentralized method of presentation was chosen in the interests of clarity and continuity for each sub-report section. Each sub-report can be read and interpreted independent of the other sub-reports. The results of each sub-section

are discussed in an integrated fashion under the main discussion section following the 9 sub-section reports. All appendices referred to in this report and the sub-reports can be found together at the end of this report.

TEST SUB-REPORTS

METHODS

RESULTS

DISCUSSION

CONCLUSIONS

ACTIVITY PATTERNS

ACTIVITY PATTERNS

Methods

Two methods were used to determine if the extent and patterns of activity of the RLW-30 and the MRE groups were equivalent:

1) A daily log of the activities of each group was recorded by a member of each unit.

2) For a portion of the test (the final two weeks) ambulatory activity monitors were worn on the wrist by a randomly selected sample of soldiers in each group. The daily logs contained a description of each day's activities, i.e., "static with local reconnaissance" "infiltration", "exfiltration" or "set-up base camp". They also included the approximate distance traveled by each unit and the approximate load transported by the soldiers.

The activity monitors employed (actigraphs) were compact (2.5" x 3.5" x3/4"), light-weight (3 oz), microprocessor-based units. They employ a two-element piezoelectric crystal, sensitive to 0.01 g of force in all three planes of excursion, to transduce motor activity. Similar devices have previously been used in military field operations (1). The monitors were initialized to record motor activity in 3 min intervals (epochs); when soprogrammed they can record continuously for 30 days. Each individual epoch is stored in a unique memory location and retrieval is accomplished using a custom interface and an IBM compatible Personal Computer. From the minute-by-minute records of motor activity collected by the actigraph it is possible to identify periods of sleep, rest and high physical activity. During sleep only a few counts are recorded per hour while extensive physical activity produces levels as high as 300 counts per min.

Results

Daily Logs: According to the report received from the RLW–30 group, they traveled a total of approximately 46 km on foot. This included marches of 1–8 km with loads of up to 100 lbs and local reconnaissance missions with noloads. On a few days there was little activity. The MRE group reported total travel on foot of 48 km, which included 1.5 to 10 km movements with up to 100 lbs of equipment as well as local reconnaissance missions with no loads. As with the RLW–30 group, this group reported that there were days with little movement.

Activity Monitors: The version of the actigraphs used in this study did not prove to be sufficiently sturdy to survive the rigors of field use. Due to equipment failures, complete data sets were recorded from only two subjects: one from the MRE group and one from the RLW–30 group. A detailed examination and comparison of these data sets (Figure 1) indicated that the individuals sampled were quite similar in total activity, total rest, the timing and extent of sleep, and the amount of sustained, high intensity physical activity. Comparisons with partial data sets recorded from other subjects in the appropriate groups indicated that the individuals with complete data sets were representative of their groups.

Conclusions

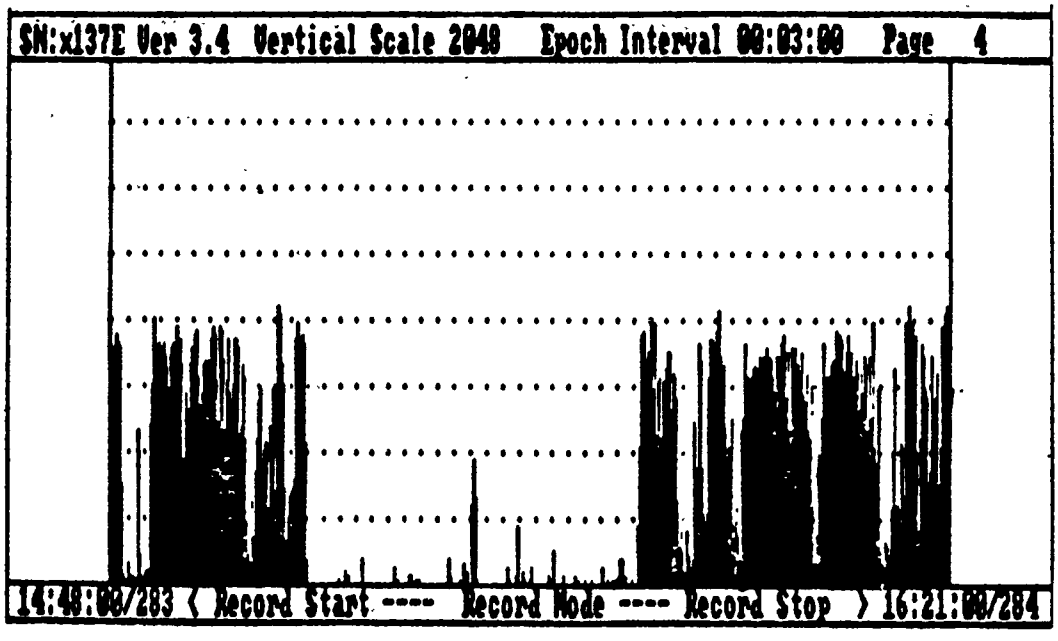
1. Based on both the logs of each group and the data collected by the activity monitors it appears that the pattern and extent of activity of the groups assigned to each ration were quite similar.
2. Each group conducted similar operations and traveled the same distances carrying similar loads.
3. Their patterns of activity as measured by the actigraph activity monitoring systems were similar in all respects.

REFERENCES

1. Redmond, D.P. & F.W. Hegge. Observations on the design and specification of a wrist-worn human activity monitoring system. Behavioral Research Methods, Instruments, and Computers, 6: 650-669, 1985.

FIGURE LEGEND

Fig. 1 Representative patterns of spontaneous motor activity recorded by actigraph worn on the wrist of the non-preferred hand. Each single line on the x-axis represents the total activity for a three minute time period. The upper record was recorded from a soldier in the MRE group, the lower record from a soldier on the RLW-30 ration. Both records begin on October 10 at 14:48 and end at 16:21 on October 11. The similarities in activity patterns across the ration groups are readily apparent. The segment where little or no activity is present are sleep periods.


SN:x137E Ver 3.4 Vertical Scale 2048 Epoch Interval 00:03:00 Page 4
14:48:00/283 < Record Start ---- Record Mode ---- Record Stop > 16:21:00/284

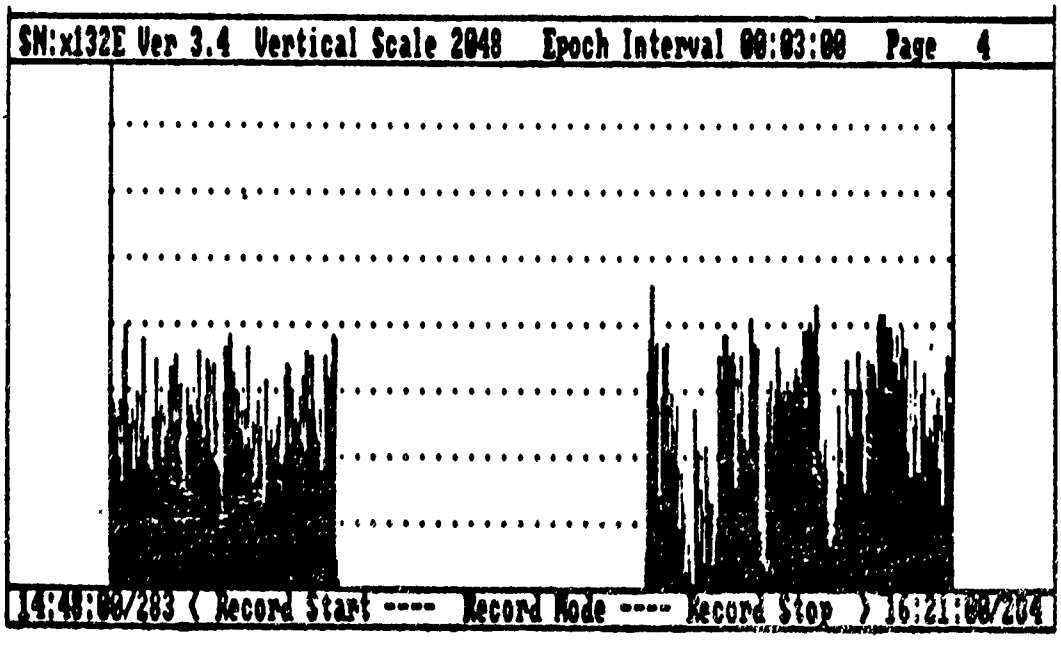

SN:x132E Ver 3.4 Vertical Scale 2048 Epoch Interval 00:03:00 Page 4
14:48:00/283 < Record Start ---- Record Mode ---- Record Stop > 16:21:00/284

FIGURE 1

FOOD CONSUMPTION and NUTRIENT INTAKES

FOOD CONSUMPTION and NUTRIENT INTAKES

Methods

Food consumption, water intakes, hedonic ratings of food items, and reasons for not finishing a food item were self-recorded daily in individual log books. These log books have been successfully used in previous packaged ration field studies and require minimum time and effort on the part of the test subjects. The test subject selected the food item he had just consumed from a list of component ration food items in the log book and circled his estimate of degree of consumption (1/4, 1/2, 3/4 or all) of the food item. Water used for hydration of food items was estimated in terms of canteen cups (700 ml) and drinking water was estimated in terms of canteens (930 ml). A separate page of food and water records was provided for each day of the week. New log books were issued each week. All test subjects received individual training and instruction on food and water recording by a dietitian prior to the start of the study. Each test subject was individually interviewed at the completion of each week by the same dietitian. Log books for the week just completed were reviewed with the test subject to verify accuracy and completeness of entries. Subjects were permitted to save food items to be eaten later but had to record the food item on the day it was consumed. RLW-30 test subjects were discouraged from trading food items with members of their ration group, but MRE subjects were permitted to trade as long as they recorded the food item when it was consumed. Sample pages from the food log books are shown in Appendix 3.

Nutrient intakes were calculated from nutrient composition of the individual food items factored against food item consumption data recorded in the log books. Nutrient composition data was provided by Natick Research Development and Engineering Center. A computerized nutrient analyses system developed by USARIEM

for the 1985 CFFS-FDTE for data reduction on a VAX 780 computer was utilized to compute nutrient intakes (1). Mean daily nutrient intakes were calculated daily, weekly and for the entire 30 day test period. Thirty day nutrient means are the means of 17 men x 30 days = 510 man days. Nutrient intakes reported for this study include kilocalories, protein, carbohydrate, fat, vitamin A, vitamin D, vitamin E, ascorbic acid, thiamin, riboflavin, niacin, vitamin B_6, folacin, calcium, phosphorous, magnesium, zinc, iron and sodium. Group mean nutrient intakes were compared to the Military Recommended Dietary Allowances (MRDA) found in AR 40-25 (2). The MRDA specifies a range of values for several nutrients. In these instances, the lower value for the specified range was used for comparisons to actual nutrient intakes. The lower value was selected because the mean age for this group of soldiers was 27.

Nutrient intakes were compared by a 2-way ANOVA with repeated measures for weeks 1, 2, 3 and 4 (3). When significant main effects of ration or time were noted, a Student-Newman-Keul post hoc test was conducted to distinguish significant time effects (3). A non-paired T-test was utilized to test for ration effects during each week (4). A 1-way ANOVA was used to compare the 30 day mean nutrient intakes between the MRE and RLW-30 group (4). These statistical comparisons were conducted according to a statistical analysis system (SPSS-X) adapted to a VAX 780 mainframe computer (5). All values shown represent the $\bar{x} \pm$ SEM for 17 subjects/group. The $p<0.05$ statistical significance was used throughout this report. All nutrient intakes are reported as the mean value/man/day for the time period indicated.

Results and Discussion

Daily energy intakes for the 30 day test period are shown in Figure 1. As was anticipated, the daily kcal intake for the RLW-30 group was close to the maximum content of the ration (1946 out of the 1976 kcal). The MRE group, on the other hand, recorded more variable daily kcal intakes but still maintained a relatively constant intake over the 30 day period. The MRE group was provided a maximum of 4023 kcal/day available to take to the field each week. A record of food selections for the first two weeks of the study indicated that the MRE group actually took only 3600 kcal/day with them and consumed approximately 77% (2782 kcal/day) of the food they took with them. The RLW-30 group, on the other hand, took all of their ration with them and consumed 98% of the ration.

Compliance during this 30 day study was good. The results of an anonymous "amnesty" questionnaire administered on the last day of this 30 day test indicated that only 8 out of the 17 subjects on the RLW-30 ration consumed food other than that contained in their ration. The total extra non-ration calories amounted to an average of only 1072 kcal/man/30 days for those 8 individuals. Only 2 subjects from the MRE group reported consuming any non-ration food.

Weekly means for nutrient intakes are shown in Figures 2-6 . These results show the differences in nutrient intakes between groups and compare the weekly nutrient intakes to the MRDA. There were significant ($p<0.05$) ration and time effects. Nutrient consumption was higher during week 4 for the MRE group but somewhat lower for the RLW-30 group. Week 4 encompassed 3 days of testing in fixed facilities with more time and a greater opportunity to heat and prepare the ration components. This may have contributed to the +200 kcal/day increase in MRE ration consumption for this week. The RLW-30 group, on the other hand, had in

some instances consumed food items from the 4th week's rations during week 3 (contrary to instructions). This resulted in less ration available for consumption during the final week. The caloric differential between week 3 and week 4 was a -112 kcal/man for the RLW-30 group.

Thirty day mean nutrient intakes for the MRE and RLW-30 groups compared to the MRDA are shown in Table 1. Both ration groups fell short of the 3200 kcal/day energy requirement recommended by the MRDA for moderate activity. The MRE group met the MRDA for all nutrients except calcium and magnesium. Fat intakes were safely below the maximum recommended amount of 160 g/day. Thirty-eight percent of the kcal came from fat for the MRE ration group. Carbohydrate intakes were adequate at 318 g/day, but not optimum. Sodium intakes averaged 1815 mg/1000 kcal of diet. This was slightly in excess of the 1700 mg/1000 kcal recommended for military rations.

The RLW-30 group did not meet the MRDA for protein. This was as anticipated, because of guidance from U. S. Army Research Institute of Environmental Medicine (USARIEM) and the Office of the Surgeon General (OTSG)* to limit protein and sodium content of this ration to conserve water requirements. The 64 g/day protein intakes were below the luxus 100 g/day MRDA but were above the RDA (Recommended Dietary Allowances, 9th revised edition, 1980) of 56 g/day (6). Sodium intakes of 1412 mg/1000 kcal (2748 mg/day) were below the 1700 mg/1000 kcal MRDA guidelines but within the 1100 - 3300 mg/day range of values recognized as safe and adequate by the RDA. Protein and sodium intakes were compatible

---

*Reference minutes from the Committee on Military Nutrition, National Research Council, Food and Nutrition Board National Academy of Sciences, Washington, D.C. Subject: "Design of a long range patrol ration," dated 17 May 1984 and letters from USARIEM (SGRD-UE-MN) to FED/NRDEC, Subject: "Ration Lightweight 30 Days: Nutritional Guidance," dated 11 Sep 1984 and 7 May 1986.

with OTSG guidelines, although sodium intakes were somewhat lower than the amount advised. Fat intakes were below the 160 g/day maximum, but comprised 46% of the kcal compared to 38% for the MRE group. Carbohydrate intakes were below 200 g/day. This level of carbohydrate intake would not be adequate for muscle glycogen replenishment with moderate to heavy physical activity (7), although with time, metabolic adaptation to this diet might reduce the relative importance of dietary carbohydrate. All other nutrient intakes were adequate for the RLW-30 group with the exception of vitamin A. The usual magnitude of the body's stores of the fat soluble vitamin A suggest that this shortcoming was probably not serious over a 30 day time period. The calcium intake of 806 mg for the RLW-30 group was adequate and an improvement over that achieved by the MRE group (694 mg).

The comparison of nutrient intakes of these two rations over a 30 day time period showed a relatively uniform (not sporadic) pattern of consumption. The MRE group consumed adequate amounts of all nutrients except for calcium and magnesium. These two minerals are especially important for bone formation, maintenance and repair. The fortification of the MRE ration with calcium and magnesium should be considered if this ration is to be used for time periods of greater than 10 days. The sub-optimum energy consumption with this ration has been noted in previous studies (1,8-10). This usually is accompanied by less than optimum carbohydrate intakes. The 318 g/day carbohydrate intake observed in this study is adequate for moderate physical activity but might not be adequate for repletion of muscle glycogen levels during strenuous chronic aerobic type exercise of long duration (i.e. jogging or marching with packs). Chronic depletion of muscle glycogen without adequate repletion has been shown to reduce the capacity for endurance exercise (11,12). The beverage powder provided with this ration provided 34 g of carbohydrate and 136 kcal per

packet (potentially 102 g carbohydrate and 408 kcal/day). It was anticipated that the addition of this beverage powder to the MRE VI ration along with larger entree portions would increase energy intakes and carbohydrate intakes. The soldiers consumed an average of 60 g carbohydrate and 240 kcal per day from the beverage powder (1.8 beverage powder packets/man/day). This resulted in a beneficial effect upon total kcal and carbohydrate intakes. The energy intakes of the MRE ration in relation to body weight changes will be discussed in the next section of this report.

The low energy, protein, carbohydrate and sodium intakes observed for the RLW-30 group were anticipated due to the design and nature of the ration. These limitations were a result of the trade-off of reduced bulk and weight against kcal. Consideration should be given to increasing the carbohydrate content of the RLW-30. With the exception of vitamin A, all other nutrient intakes were adequate for the RLW-30 group. The vitamin A content of the RLW-30 should be increased by fortification of the diet. The 806 mg/day calcium intake of the RLW-30 group was superior to that of the MRE group. The calcium content of the MRE ration should be increased by fortification of the diet.

Conclusions

1. Nutrient intakes for the MRE VI group were adequate except for calcium, magnesium and energy. The energy deficit was not severe since weight loss was only 2.2% for the 30 day time period (Refer to next sub-report on Nutritional and Hydration Status).

2. Nutrient intakes for the RLW-30 group were adequate except for energy, protein, vitamin A and sodium. Energy and protein were intentionally constrained by the design and purpose of the ration. Vitamin A and sodium intakes were marginally low and should be increased by additional fortification.

3. Carbohydrate intakes for the RLW–30 group were not adequate to support glycogen repletion that would be required in the event of chronic strenuous physical activity. Low carbohydrate intakes (like energy and protein) were also a consequence of the restraints inherent in the design of this low volume lightweight ration.

REFERENCES

1. Combat field feeding system–force development test and experimentation (CFFS–FDTE) Test Report. USACDEC, Ft. Ord, CA. and USARIEM, Natick, MA. Test Report CDEC–TR–85–006A, 1986.

2. Nutrition Allowances, Standards, and Education. Army Regulation 40–25. Headquarters, Department of the Army, the Navy and the Air Force. Washington, D.C, 15 May 1985.

3. Zar, J.H. Biostatistical Analysis. Prentice–Hall, Englewood Cliffs, N.J. 1974, pp 151–181.

4. Steele, R.G.D. and J.H. Torrie. Principles and Procedures of Statistics. McGraw–Hill Co. New York, New York. 1961, pp 67–87, 99–131.

5. Norvis, M.J. SPSSX Advanced Statistics Guide. McGraw–Hill CO, New York, New York. 1985.

6. Recommended Dietary Allowances. Committee on Dietary Allowances, Food and Nutrition Board, Division of Biological Sciences, Assembly of Life Sciences, National Research Council, 9th ed., Washington, D.C. National Academy Press, 1980.

7. Costill, D.L., W.M. Sherman, W.J. Fink, C. Maresh, M. Whitten and J.M. Miller. The role of dietary carbohydrates in muscle glycogen resynthesis after strenuous running. Am. J. Clin. Nutr. 34:1831 –1836, 1981.

8. Hirsch, E., H.L. Meiselman, R.D. Popper, G. Smits, B. Jesior, I. Lichton, N. Wenkam, J. Burt, M. Fox, S. McNutt, M.N. Theile, and O. Dirige. The effects of prolonged feeding, Meal, Ready–to–Eat (MRE) operational rations. USANRDC Technical Report, No. TR–85/035 1983.

9. Askew, E.W., J.R. Claybaugh, S.A. Cucinell, A.J. Young, and E.G. Szeto. Nutrient intakes and work performance of soldiers during seven days of exercise at 7,200 feet altitude consuming the meal, ready–to–eat ration. U.S. Army Research Institute of Environmental Medicine Technical Report No.T3–87. 1986.

10. Popper, R.D., E. Hirsch, L. Lesher, D. Engell, B. Jezior, B. Bell and W.T. Matthew. Field evaluation of improved MRE, MRE VI, and MRE IV. NRDEC Technical Report (in preparation). 1987.

11. Bergstrom, J.,L. Hermansen, E. Hultman, and B. Saltin. Diet muscle glycogen and physical performance. Acta. Physiol. Scand. 71:140–150. 1967.

12. Sherman, W.M. and D.L. Costill. The marathon: dietary manipulation to optimize performance. Am. J. Sports Med. 12:44–51, 1984.

41

Table 1. Thirty Day Mean Nutrient Intakes of the MRE and RLW-30 Rations Compared to the MRDA[1]

Nutrient	MRDA	MRE Group[4]	%MRDA	RLW-30 Group	%MRDA
Energy, kcal	3200.0	2782.00 ± 42.00	87	1946.00 ± 15.00 *	61
Protein, g	100.0	112.00 ± 2.00	112	64.00 ± 1.00 *	64
Carbohydrate, g[2]	440.0	318.00 ± 6.00	72	197.00 ± 2.00 *	45
Fat, g[2]	160.0	119.00 ± 2.00	74	100.00 ± 1.00 *	63
Vitamin A, mcg RE	1000.0	1021.00 ± 24.00	102	777.00 ± 14.00 *	78
Vitamin D, mcg	5.0	----------	NA	14.30 ± 0.27	286
Vitamin E, mg TE	10.0	----------	NA	118.00 ± 2.00	1180
Ascorbic Acid, mg	60.0	194.00 ± 4.00	323	92.00 ± 2.00 *	153
Thiamin(B_1), mg	1.6	5.13 ± 0.10	321	2.13 ± 0.03 *	133
Riboflavin(B_2), mg	1.9	2.09 ± 0.03	110	2.04 ± 0.02	107
Niacin, mg NE	21.0	27.02 ± 0.46	129	25.72 ± 0.24 *	122
Vitamin B_6, mg	2.2	4.03 ± 0.08	183	2.17 ± 0.04 *	99
Folacin, mcg	400.0	----------	NA	426.00 ± 7.00	107
Vitamin B_{12}, mcg	3.0	----------	NA	2.97 ± 0.07	99
Calcium, mg	800.0	694.00 ± 12.00	87	806.00 ± 11.00 *	101
Phosphorus, mg	800.0	1450.00 ± 23.00	181	1181.00 ± 10.00 *	148
Magnesium, mg	350.0	289.00 ± 5.00	83	359.00 ± 4.00 *	103
Iron, mg	10.0	17.33 ± 0.26	173	19.54 ± 0.36 *	195
Zinc, mg	15.0	----------	NA	14.75 ± 0.14	98
Iodine, mcg	150.0	----------	NA	----------	NA
Sodium, mg[3]	5440.0	5051.00 ± 83.00	93	2748.00 ± 27.00 *	51

[1] MRDA = Military Dietary Allowances from AR 40-25. Vitamin D, Calcium, Phosphorus, Magnesium and Iron are given as ranges; the lowest value of the ranges was used in calculating the % MRDA.
[2] No MRDA is established for carbohydrate or fat. The values of 440 g and 160 g for carbohydrate and fat are taken from AR 40-25 Nutritional Standards for Operational Rations. The value of 160 g for fat is a maximum amount recommended for a ration.
[3] The MRDA value for sodium is a target for military rations of 1700 mg per 1000 kcal of diet. The RDA recommends 1100-3300 mg sodium per day as safe and adequate.
[4] No values were available for Vitamin D, Vitamin E, Folacin, Vitamin B_{12}, and Iodine content of the MRE ration. No value for iodine was available for the RLW-30 RATION.
* Significantly different RLW vs MRE, $p<0.05$.

FIGURE LEGENDS

Figure 1. Daily energy intakes during the 30 day FTX. The 30 day mean energy intake for the MRE group was 2782 kcal/man/day and 1946 kcal/man/day for the RLW-30 group.

Figure 2. Weekly mean kilocalorie, protein, carbohydrate and fat intakes for the MRE and RLW-30 groups. Values are $\bar{x}$ ± SEM. The military recommended dietary allowance (MRDA) is shown as a dotted line for kilocalories (moderate physical activity) and protein. There are no MRDA's for carbohydrate and fat. The value of 440 g carbohydrate is from the nutritional standards for operational rations (NSOR). This quantity of carbohydrate is adequate to replace muscle glycogen in runners undertaking strenuous daily endurance training (12). The 160 g value shown for fat is the maximum amount recommended for operational ration content.

Figure 3. Weekly mean thiamin, riboflavin and niacin intakes for the MRE and RLW-30 groups. Values are $\bar{x}$ ± SEM. The military recommended dietary allowance (MRDA) is shown as a dotted line.

Figure 4. Weekly mean ascorbic acid, vitamin B_6 and vitamin A intakes for the MRE and RLW-30 groups. Values shown are $\bar{x}$ ± SEM. The military recommended dietary allowance (MRDA) is shown as a dotted line.

Figure 5. Weekly mean iron, magnesium, calcium and phosphorous intakes for the MRE and RLW-30 groups. Values shown are $\bar{x}$ ± SEM. The military recommended dietary allowance (MRDA) is shown as a dotted line.

Figure 6. Weekly mean sodium and potassium intakes for the MRE and RLW-30 groups. Values shown are $\bar{x}$ ± SEM. There is no military recommended dietary allowance (MRDA) for sodium and potassium. The target value for sodium is 1700 mg/1000 kcal in operational rations. The estimated safe and adequate dietary intake for potassium is 1875-5625 mg/day.

RLW-30 Test, 10TH SFG

Daily Energy Intakes

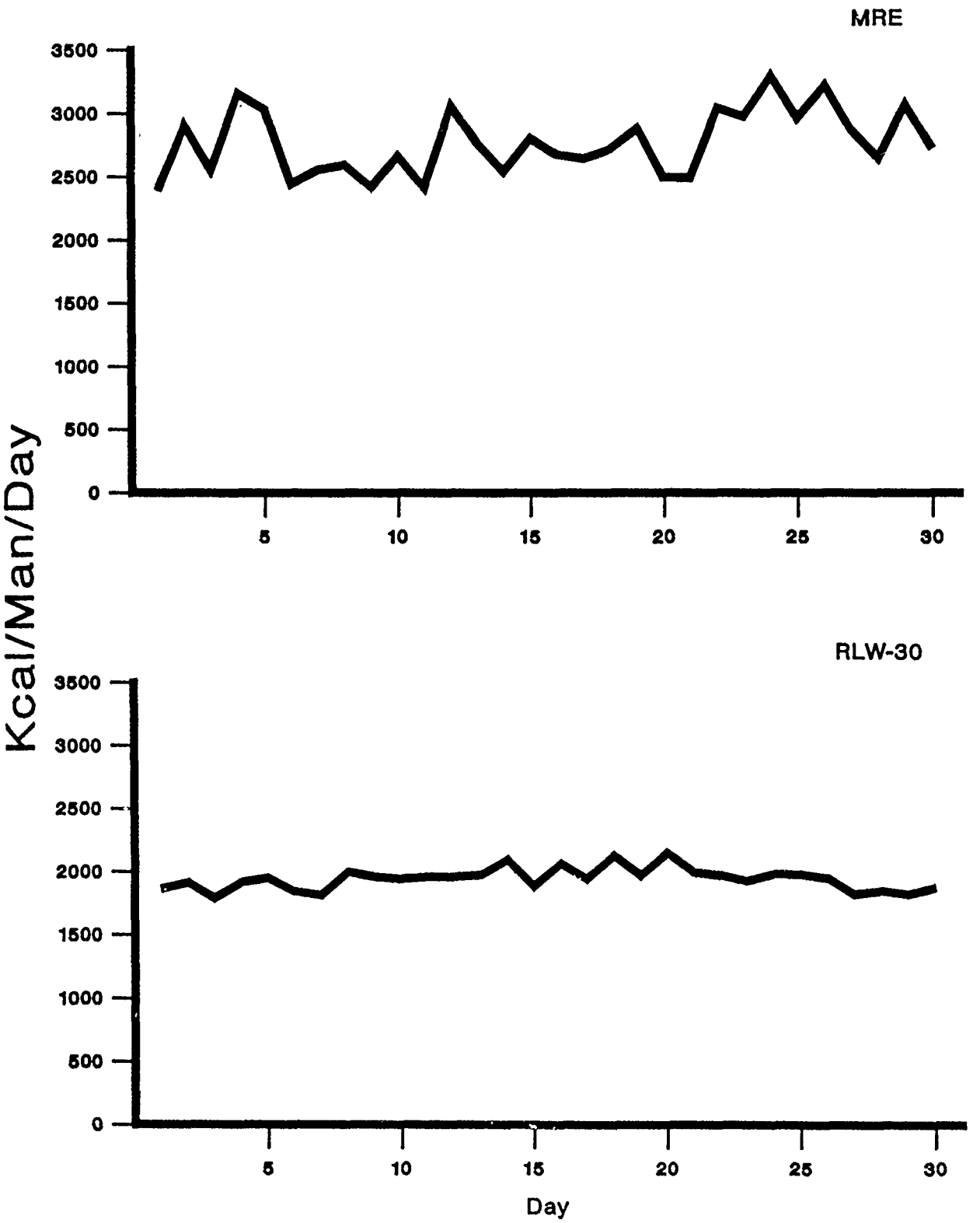


FIGURE 1

RLW-30 OT, 10TH SFG

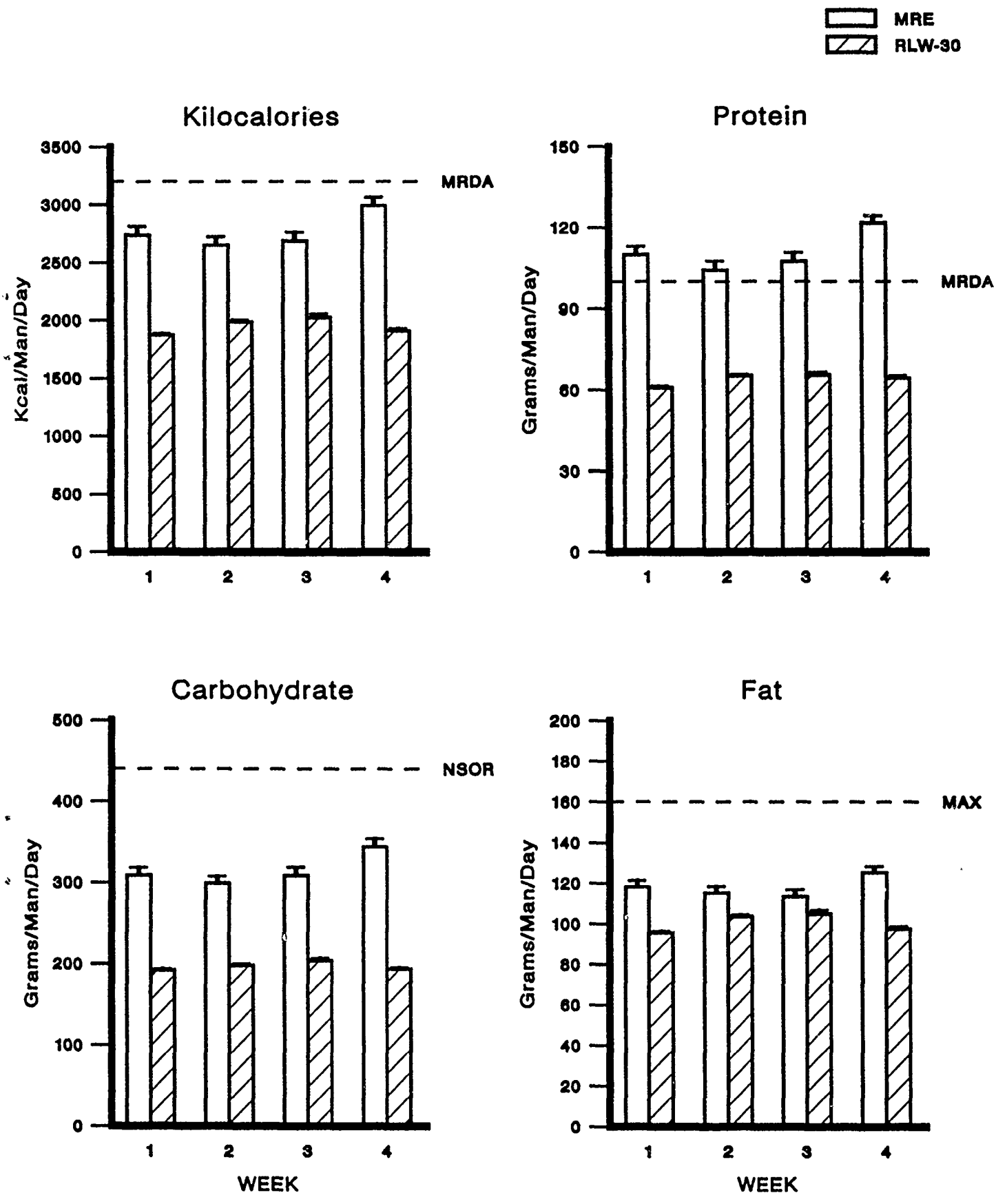


FIGURE 2

RLW-30 OT, 10TH SFG

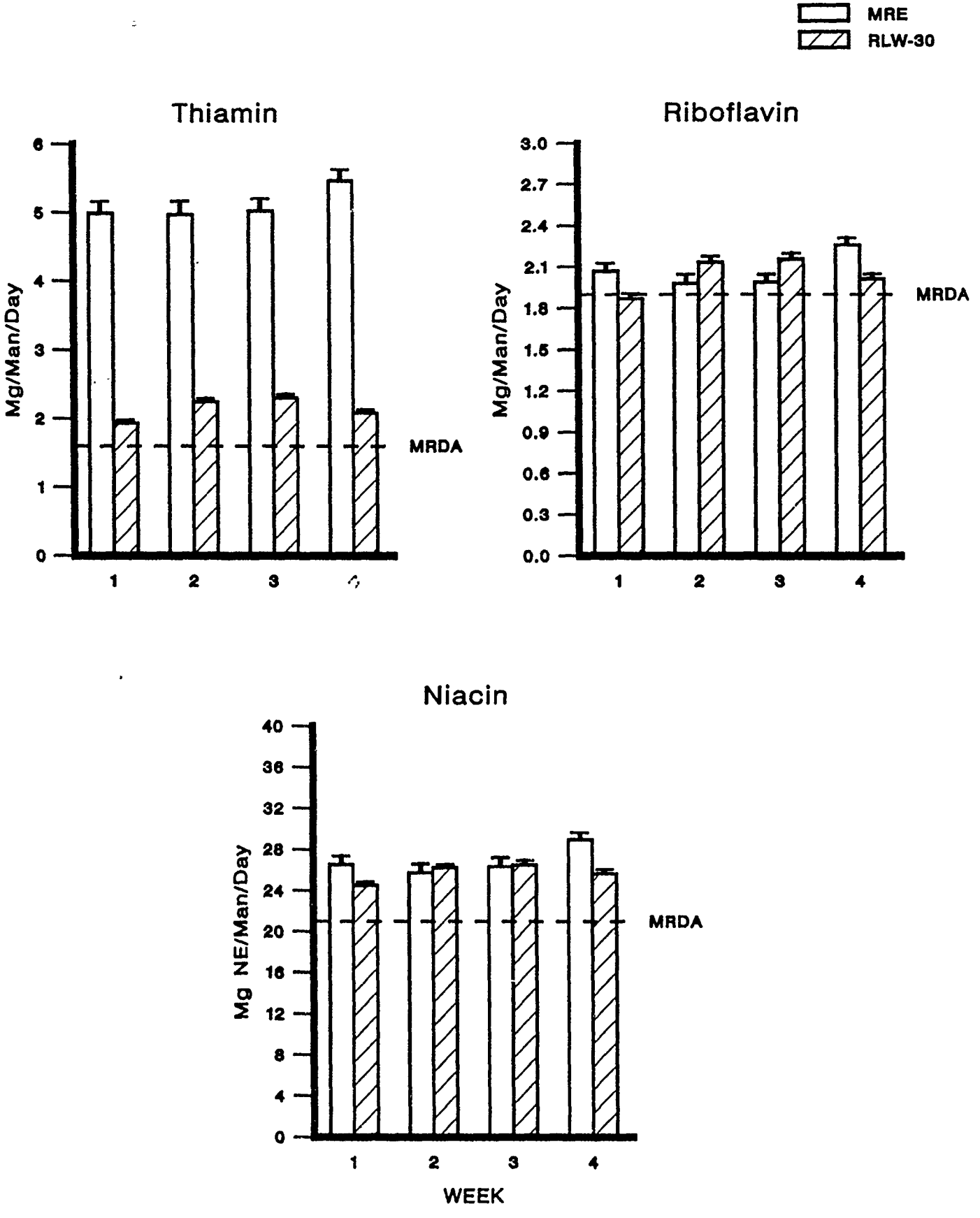


FIGURE 3

RLW-30 OT, 10TH SFG

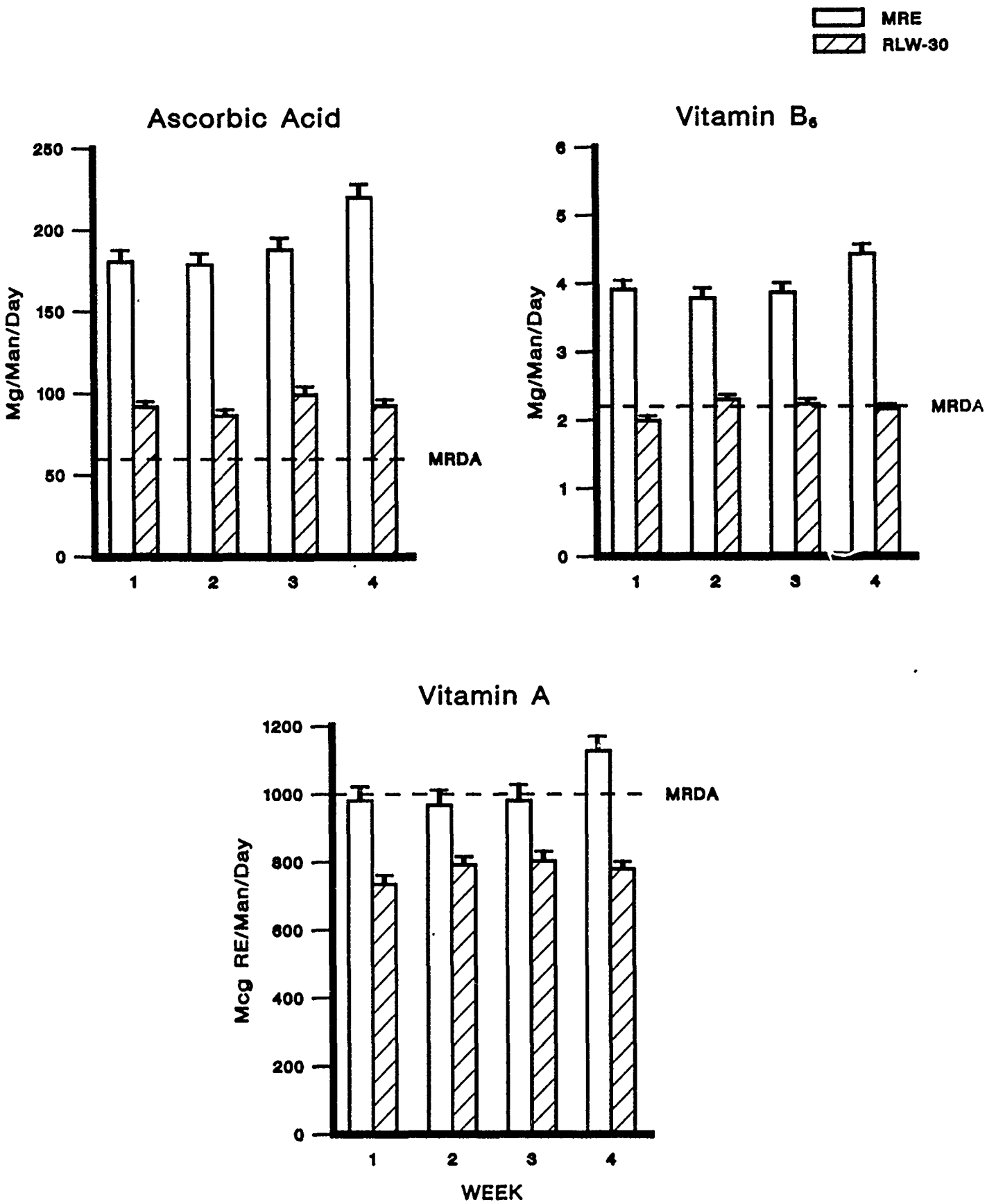


FIGURE 4

RLW-30 OT, 10TH SFG

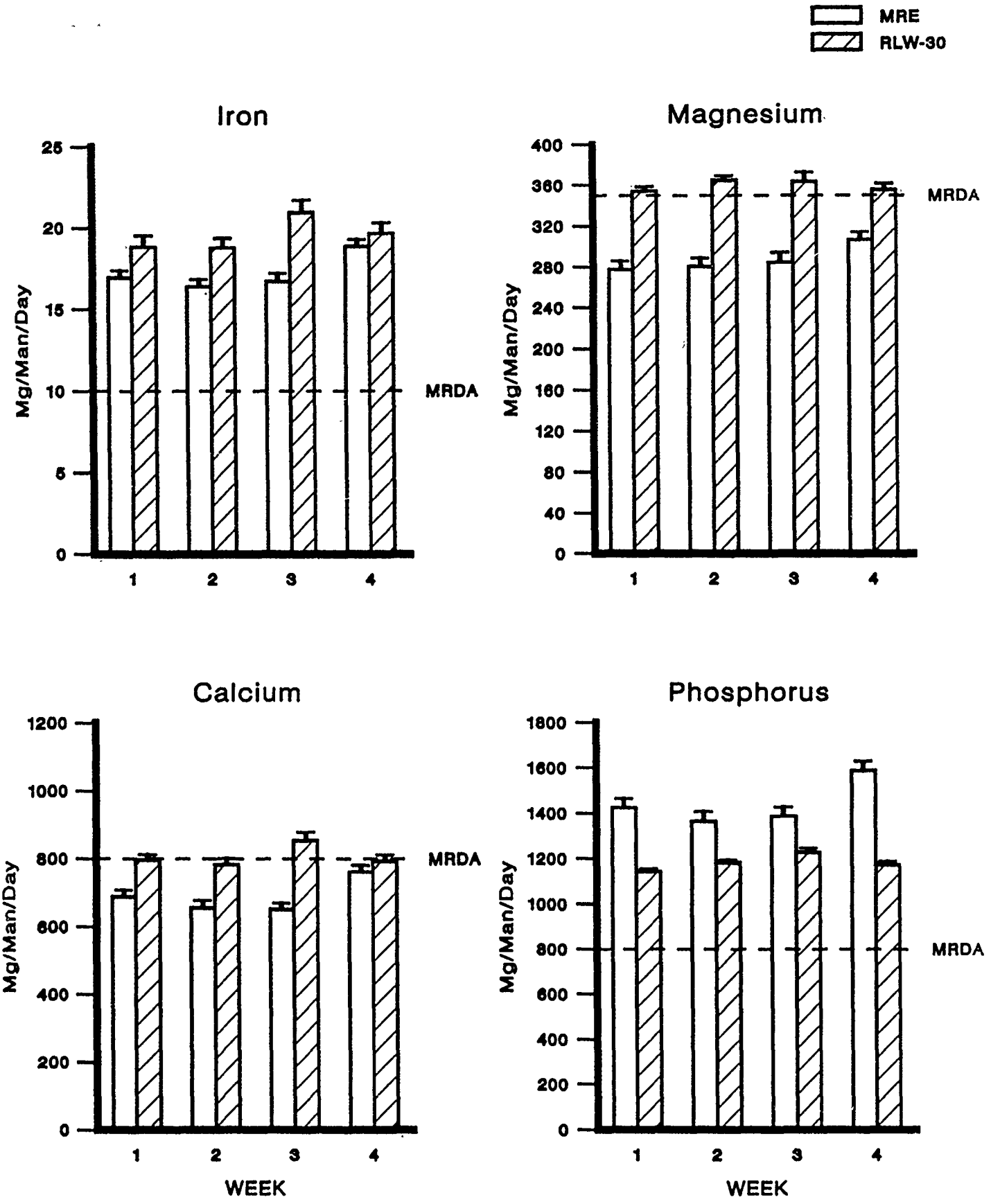


FIGURE 5

RLW-30 OT, 10TH SFG

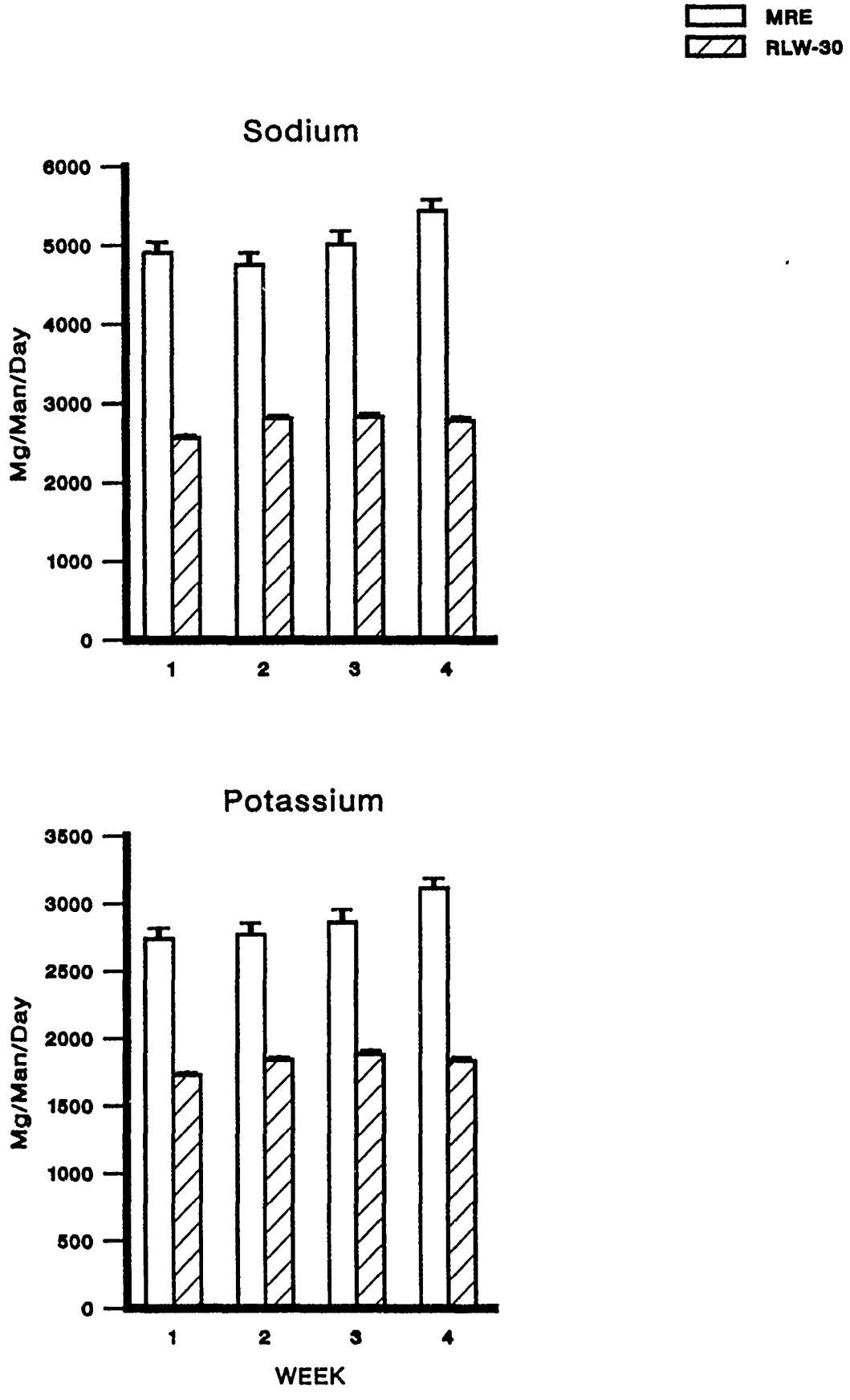


FIGURE 6

NUTRITIONAL and HYDRATION STATUS

NUTRITIONAL and HYDRATION STATUS

Methods

Test subjects were weighed 6 times during this study: day 0 (pre-test), day 7 (week 1), day 14 (week 2), day 21 (week 3), day 27 (upon return from Camp Ethan Allen to Ft. Devens), and day 30 (post-test). Body weights were taken at 0630 before breakfast following an overnight fast, except for day 27, which was taken at 1600 hrs upon arrival at Ft. Devens. The men were weighed in the same standard condition each time: T-shirts, fatigue trousers with the pockets empty, and in stocking feet. The balances were digital electronic platform scales accurate to ±0.1 lb (SECA model 770). Body weights were taken in duplicate on 2 identically pre-calibrated balances. The mean weight of those two determinations was recorded. A seventh weight of the RLW-30 group was taken 3 1/2 weeks after the completion of the study as a follow-up to determine if body weights had returned toward pre-test values.

Urine ketones and specific gravity were estimated daily by testing first void in the morning urine with urine dipsticks (N-Multistix, Ames Division, Miles Laboratories). Each test subject was furnished with a kit containing indicator dipsticks, a color chart and a log book for recording the readings (Appendix 4). These readings are semi-quantitative in nature. The ketone measured by this method is acetoacetate and the scale is calibrated in increments of 5, 15, 40, 80 and 160 mg/dl corresponding to trace, small, moderate, and large ketonemia respectively. Specific gravities are calibrated in increments of 0.005 units with values $\leq$1.025 taken as indicative of normal hydration and values of >1.030 indicative of concentrated urine or dehydration. In addition to the daily dipstick tests, urine samples (first

void) were collected weekly and tested for specific gravity and osmolarity by a trained laboratory technician using a refractometer (TS meter, American Optical Model 10400A) accurate to ± 0.001 units and a freezing point depression osmometer.

Blood samples (antecubital venous) were collected on days 0, 15 and 30 and analyzed for hemoglobin and hematocrit. Hemoglobin and hematocrit values reflect changes in plasma volume and/or iron status. Serum, plasma and erythrocytes were collected and frozen for subsequent analyses indicative of nutritional status. These results will be presented as a separate technical report.

The hydration status of the subjects was assessed by a series of related measures: urine specific gravity, fluid intakes, and urine volumes. Fluid intakes were recorded daily in terms of canteen cups and canteens of water consumed. Food source water was calculated from food intakes. Urine volumes were measured on 24 hour urine collections on day 1, day 15, and day 30.

Body weight changes, urine specific gravities, urine volumes, fluid intakes, hemoglobins and hematocrits were compared by a 2-way ANOVA with repeated measures (1). When significant main effects of ration or time were noted, a Student-Newman-Keul post hoc test was conducted to distinguish significant time effects (1). A non-paired T-test was utilized to test for ration effects during each week (2). Comparisons of 30 day means between ration groups was accomplished with a 1-way ANOVA (2). These statistical comparisons were conducted according to a statistical analysis package (SPSS-X) adapted to a VAX 780 mainframe computer (3). All values shown represent the $\bar{x}$ ± SEM for 17 subjects/group.

Results and Discussion

Body weight changes are shown in Figures 1 and 2. Individual body weight changes are shown in Tables 1 and 2. Examination of cumulative body weight losses for the 30 day period showed that the MRE group lost 4.0 ± 1.3 lbs/man compared to 11.4 ± 1.1 lbs/man for the RLW-30 group. These weight losses corresponded to 2.2 and 6.3% of initial body weights respectively. The weight loss of the MRE group was less and that of the RLW-30 group was greater than the OTSG criterion (3%) for body weight loss used during the 1985 CFFS-FDTE (4). Both groups lost a significant amount of body weight, but the weight loss for the RLW-30 group was significantly greater ($p<0.05$) at each week and at the end of 30 days compared to the MRE group.

A calculation of energy requirements for the average soldier of the RLW-30 group is presented in Appendix 5. This calculation was made by calculating resting metabolic rate based upon weight, height and age and adding to this value allowances for light, moderate and heavy activity (5). This calculation is dependent upon several assumptions regarding level and duration of activity and is an estimate; however, this estimate can be validated with a certain degree of assurance by another independent estimate of energy requirement based upon known energy intake and observed body weight loss. The latter estimate requires an assumption regarding the caloric equivalency of weight loss. For the purposes of this calculation it was assumed that 1 lb of body weight loss was approximately equivalent to 3500 kcal (5), although it is recognized that the actual caloric value of this weight loss is variable depending upon its composition (water, protein, fat). Grande and Keys (6) state that the caloric equivalent of body weight loss can range from 1200-3200 kcal/lb depending upon the period of time during caloric restriction that the measurement is made.

The calculated energy requirement of the RLW–30 group (based upon activity estimates) was approximately 3400 kcal/man/day. This estimate of energy requirement is dependent upon the accuracy of estimates of activity levels. These estimates were somewhat arbitrary due to the variety of missions performed in this FTX. A more accurate estimate of energy requirements can be made from caloric intakes and body weight loss, provided the weight loss is not due to dehydration. Calculated energy requirements for the MRE group based upon an average daily caloric intake of 2782 kcal and a 30 day weight loss of 4.0 lbs was 3250 kcal. A similar calculation for the RLW–30 group based upon an average daily caloric intake of 1946 kcal/day and a 30 day weight loss of 11.4 lbs was 3275 kcal. These calculations are in relatively close agreement and suggest that the energy expenditures of the soldiers during this 30 day FTX were in the range of 3200–3400 kcal/day. A further check on the validity of the data gathered in this study can be made by comparing the calculated body weight loss (projected weight loss) with the actual observed body weight loss. This calculation is presented in Appendix 5. A comparison of the 30 day energy expenditure with the 30 day energy intakes of the RLW–30 group indicates a 30 day caloric deficit of approximately 48,120 kcal/man. Assuming a caloric equivalency of 3500 kcal/lb of body weight (5), it can be projected that this group should have lost 12.4 lbs of body weight. The actual value observed was 11.4 lbs. The difference in these two values is probably related to the actual composition of this weight loss and/or shifts in basal metabolic rate or the caloric costs of work as the study progressed. Other investigators have noted that during long term caloric restriction body weight changes are usually smaller than predicted from observed energy intakes (7). This is believed to be due to a decrease in basal metabolic rate and a general decrease in oxygen consumption for similar amounts of work of moderate intensity (7).

The 11.4 lb, 6.3% body weight loss for the RLW-30 group was less than the 13-14 lb, 8-9% body weight loss predicted before the study was conducted. This prediction was based upon a projected daily kcal requirement of 3600 kcal/man/day. The actual energy requirements for weight maintenance for both groups (based upon recorded energy intakes and body weight loss for this 30 day time period and activity records) was approximately 3200-3400 kcal/day. Special operation missions requiring a higher level of physical activity than those conducted during this test would be accompanied by proportionally greater body weight losses. The greatest body weight loss occurred during week 1 (4.8 lbs). The RLW-30 group lost 4.8, 2.6, 1.6 and 2.4 lbs/man/week during weeks 1, 2, 3 and 4, respectively. During the first few days on a calorically deficient diet the body tends to lose more water than fat. Later, after the body begins to make metabolic adjustments, further body weight loss represents a combination of water, protein and fat (6). Such body weight loss tends to be exponential rather than linear. Although it is difficult to generalize from these data, it appears that approximately 5.0 lbs will be lost during the first week and approximately 2.5 lbs for each subsequent week thereafter that this ration is utilized, for time periods of up to 4 weeks. Considerable individual variation can occur in body weight loss.

Body weights were taken 25 days after the end of the FTX for 12 available members of the RLW-30 group. Their weights are shown in Table 3. Three of the 12 had lost a further small amount of body weight (2-4 lbs). Nine of the 12 had gained back an average of 5.9 lbs. The mean 25 day recovery of body weight for all 12 individuals was 4 lbs or 36% of the original weight loss. Four of the remaining members of the group who were not available to be weighed 25 days after the FTX were weighed 55 days after the end of the FTX. Their weights are shown

in Table 4. Three of the 4 had gained 2–6 lbs; one individual had maintained the weight he had achieved on day 30. The results of the reweighing in the post–recovery period indicates that the weight loss manifested at the end of the 30 day FTX was probably true weight loss, not just body water due to dehydration. It also indicates that the regaining of body weight lost during the FTX was a slow process. Only 2 of the 16 individuals had gained back the weight they had lost 3 1/2 weeks after the period of weight loss. It is not known to what degree the Army weight control program motivated the soldiers to try to maintain their reduced weight status. The RLW–30 group was 10.6 lbs heavier initially than the MRE group. It is possible that "defensive eating" by the RLW–30 group prior to the ration test may have resulted in a heavier beginning body weight than normal. Weight regained after the test would probably not be expected to return to the higher departure point.

The heaviest soldier in the RLW–30 group lost the most body weight, 21.7 lbs or 9.9% of his original body weight. For this particular individual, 74% of the weight loss came from body fat and 26% came from lean body mass. The leanest individual (9.1% body fat initially) lost 5.2% of his original body weight of which 76% came from body fat and 24% came from lean body mass. The components of the weight loss for the entire RLW–30 group were 63% of the weight loss from body fat and 37% from lean body mass. A complete presentation and discussion of the composition of the weight loss observed in this study (fat vs lean body mass) and its effect upon physical performance is presented in the sub–section of this report on Muscle Strength and Endurance, Aerobic Capacity and Body Composition. It is appropriate here to discuss the loss of lean body mass relative to the kcal and protein content of the ration. Protein intakes for the RLW–30 group were 64 g/day.

As mentioned earlier, the protein content of this ration was intentionally kept low to reduce its water burden. The excretion of excess urea nitrogen resulting from deamination and oxidation of excess dietary protein for energy requires approximately 50 ml of water/g of urea nitrogen and is contraindicated from the standpoint of water balance (8). A review of nitrogen balance as it relates to calorie and protein intake by Calloway and Spector (8) indicated that at protein intakes of 68–75 g/day calories were limiting to nitrogen balance, up to 2500 kcal/day. At calorie intakes of 1400–2300 kcal/day, 44–56 g of protein/day results in essentially the same sparing of body protein as intakes up to 75 g/day. Energy intake seems to have a greater effect on nitrogen balance than protein intake in marginally adequate ranges of intake (9). This suggests that the protein intake supplied by this ration was adequate under the circumstances and any attempt to alleviate negative nitrogen balance and loss of lean body mass with this ration should be directed toward increasing the caloric content.

The body weight change of this 30 day FTX was more likely due to changes in body fat and lean body mass rather than a loss of body water due to dehydration. Thirty days is an adequate period of time for body water equilibration. There was no evidence of dehydration at the end of the study when body composition measurements were made, based upon fluid intakes and urine volumes and specific gravity.

The results of the daily urine dipstick tests for ketones are shown in Figure 3. The MRE group displayed none to trace amounts of ketones as would be anticipated for situations where energy intake and energy expenditure were similar. The RLW–30 group, on the other hand, consumed approximately 830 kcal/man/day less than the MRE group and were in negative energy balance. This was reflected in a

slightly higher (trace) level of urine ketones. The urinary ketone level displayed by the RLW-30 group was not indicative of a severely ketotic state but did reflect the negative energy status of this group.

The daily urine dipstick specific gravities recorded in the log books were generally similar for both groups (Figure 3). Although the dipsticks seemed to indicate that the specific gravities for the RLW-30 group were slightly higher than the MRE group, the opposite relationship was noted for the weekly refractometer determinations. Urine dipstick specific gravities are not as sensitive or accurate as refractometer measurements and tend to give higher readings than the refractometer values shown in Table 5. Refractometer urine specific gravities and freezing point depression urine osmolalities are shown for 9 sampling dates in Table 5, and at weekly intervals in Figure 4. The normal range for urine specific gravity is 1.016-1.022 (10). Values>1.030 indicate a lack of adequate hydration. The MRE group generally had a greater occurance of specific gravities >1.030 at the end of weeks 1, 2, and 3 (Table 5). There was no significant main effect due to ration, but there was a significant main effect due to time, $p<0.05$. In general, the MRE group tended to increase urine specific gravity and osmolarity as the test progressed, returning to baseline on day 27. The RLW-30 group tended to decrease the magnitude of these variables initially and then remained relatively constant over the rest of the test. This resulted in a significant ($p<0.05$) ration x time interaction.

Twenty-four hour urine collections were made on day 1, day 15, and day 30. The results of analyses of these urine samples are shown in Table 6. There were no significant overall main effects due to ration for the 24 hour urine measurements; this agreed with the specific gravity and osmolality tests conducted on the weekly first void in the morning urine samples shown in Table 5. There was a significant

difference between the MRE and RLW-30 groups for the 24 hour urine samples collected on day 15 that was not reflected in the overall test of main effects due to ration. The RLW-30 group had a greater urine volume and lower specific gravity and lower solute concentration in the urine than the MRE group. This was probably due to the greater intake of fluids recorded during this time period for the RLW-30 group (see sub-report on Water Intakes and Fluid Consumption Patterns). Although the MRE group consumed more sodium and protein than the RLW-30 group, there were only small differences in total solute excretion. The lower water intake of the MRE group probably accounts for their higher specific gravities shown in Table 5 and 6.

Taken together, these results on urine indicators of hydration status suggest that the RLW-30 group consumed enough fluids to excrete urine that was not excessively concentrated. There were no indications of dehydration in either group. The RLW-30 group gave some indications of being in a slightly better hydration status than the MRE control group.

Urine specific gravities approaching 1.030 have been reported in field studies utilizing MRE rations not supplemented with a beverage powder (4). The MRE VI ration utilized as the control ration in this test was supplemented with a beverage base powder (135 kcal, 34 g CHO per beverage packet). An average of 587 ml of water/man/day was consumed as a result of hydrating this beverage powder. This stimulus for increased fluid intake appeared to be successful in improving the hydration status of soldiers consuming the MRE ration. The beverage powder consumption also contributed 60 g carbohydrate and 240 kcal/man/day. The beneficial effect of a beverage powder on hydration status has also been noted in a recent 10 day field test of a similar improved MRE ration (11).

The MRE group consumed approximately 3.4 L water/man/day. Studies done in 1983, 1984 and 1986 in a temperate environment in Hawaii have reported fluid intakes ranging from 2.7 to 4.3 L/man/day for soldiers consuming the MRE ration (11,12,13). The RLW-30 group consumed approximately 4.4 L water/man/day. Food source water accounted for approximately 20 ml/man/day for the RLW-30 group compared to approximately 370 ml/man/day for the MRE group. This reflects the differences in degree of dehydration of the food components of the two rations and points out that soldiers consuming the RLW-30 ration must secure approximately 350 ml of additional water/day (1/2 a canteen cup) to compensate for the lack of food source water in their ration. The RLW-30 group subjectively reported that preparing their ration with large quantities of water seemed to help their satiety for food. This appeared to be the stimulus for the 29% greater fluid intakes recorded for this group. The increased fluid intake could not be attributed to an increase osmotic load (Table 6). The beverage bar included with the RLW-30 ration did not appear to be accepted to the same degree as the beverage powder packet included with the MRE ration (refer to sub-report on Ration Acceptance, Human Factors, and Subjective Performance Ratings). This seems to say that the beverage powder water flavoring was a stimulus for fluid consumption in the MRE group, but hunger satiety was a stronger stimulus for fluid consumption in the RLW-30 group. Water intakes and fluid consumption patterns are reported in detail in the following section (Water Intakes and Fluid Consumption Patterns).

Hemoglobin and hematocrit values are shown in Table 7. There were no significant main effects due to ration. There was a significant effect due to time. Both hemoglobin and hematocrit values were elevated at the end of the first two weeks of the test. There appears to be no clinical significance to this increase. If

the increase in red cell mass was a result of an improvement in iron status due to ration, the effect should have also been evident at the time of the third blood sampling, but was not. A decrease in plasma volume with no change in red blood cell number (dehydration) would produce an apparent increase in hemoglobin and hematocrit, but there was little evidence of a change in plasma volume based upon apparent hydration status (Table 6). The results of these blood analyses indicate that there was no significant deleterious effect of time or ration on blood hemoglobin or hematocrit and imply a normal iron and hydration status.

Conclusions

1. An evaluation based upon nutrient intakes, body weight loss and hydration status indicated that the nutritional status of the MRE group was satisfactory with the exception of a slightly negative energy status. The MRE group lost 2.2% of their body weight. This weight loss approached but did not exceed the OTSG criterion of 3% established during the 1985 CFFS-FDTE. The weight loss was from the body fat component (refer to sub-report on body composition).

2. The RLW-30 group was in a predictably greater negative energy balance and incurred a moderate weight loss of 6.3%. This was less than the 10% level of weight loss established as undesirable to exceed prior to the start of the study. The absolute amount of this weight loss was acceptable but the composition of the body weight loss was not. A significant portion of the body weight loss was lean body mass (refer to sub-report on body composition). This indicates a negative nitrogen status existed in the RLW-30 group.

3. The hydration status of both groups was satisfactory. Under the conditions of this test the MRE group consumed 3.4 L of water/day whereas the RLW-30 group

consumed 4.4 L of water/day. Theoretically, the RLW-30 group needed approximately 0.35 L of water/day more than the MRE group. The observed 1.0 L increase appeared to be related to an attempt to achieve food or appetite satiety rather than to satisfy thirst (refer to sub-report on fluid consumption patterns). Urine specific gravities, fluid intakes and urine volumes indicated an adequate hydration status for both groups during the 30 day FTX.

4. A complete evaluation of the nutritional status of both groups will be published in a separate report of biochemical analyses of blood and urine samples collected in this study. A panel of clinical blood chemistries conducted pre and post FTX were within the range of normal values (refer to sub-report on medical evaluation.)

REFERENCES

1. Zar, J.H. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, N.J. 1974, pp 151-181.

2. Steele, R.G.D. and J.H. Torrie. Principles and Procedures of Statistics. McGraw-Hill Co., New York, New York. 1961, pp 67-87, 99-131.

3. Norvis, M.J. SPSSX Advanced Statistical Guide. McGraw-Hill CO., New York, New York. 1985.

4. Combat field feeding system-force development test and experimentation (CFFS-FDTE) Test Report. USACDEC, Ft. Ord, CA. and USARIEM, Natick, MA. Test Report CDEC-TR-85-006A, 1986.

5. Wilmore, D.W. The metabolic management of the critically ill. Plenum, New York, New York. 1977. pp. 1-44.

6. Grande, F. and A. Keys. Body weight, body composition and calorie status. In : Modern Nutrition in Health and Disease. Eds. R.S. Goodhart and M.E. Shils. Lea and Febiger, Philadelphia, PA, 1980, pp. 3-34.

7. Apfelbaum, M. Adaptation to changes in caloric intake. Prog. Fd. Nutr. Sci. 2:543-559, 1978.

8. Calloway, D.H. and H. Spector. Nitrogen balance as related to caloric and protein intake in active young men. Am. J. Clin. Nutr. 2:405-412, 1954.

9. Calloway, D.H. Nitrogen balance of men with marginal intakes of protein and energy. J. Nutr. 105:914-923, 1975.

10. Harry, J.B. Clinical diagnosis and management by laboratory methods. Volume 1, 16th ed. W.B. Saunders Co, Philadelphia, PA. 1979.

11. Popper, R.D., E. Hirsch, L. Lesher, D. Engell, B. Jezior, B. Bell and W.T. Matthew. Field evaluation of improved MRE, MRE VI, and MRE IV. NRDEC Technical Report (in preparation). 1987.

12. Hirsch, E., H.L. Meiselman, R.D. Popper, G. Smits, B. Jesior, I. Lichton, N. Wenkam, J. Burt, M. Fox, S. McNutt, M.N. Theile, and O. Dirige. The effects of prolonged feeding meal, ready-to-eat (MRE) operational rations. USANRDC Technical Report No. TR-85/035, 1983.

13. Askew, E.W., J.R. Claybaugh, S.A. Cucinell, A.J. Young, and E.G. Szeto. Nutrient intakes and work performance of soldiers during seven days of exercise at 7,200 feet altitude consuming the meal, ready-to-eat (MRE) operational rations. U.S. Army Research Institute of Environmental Medicine Technical Report No. T3-87, 1986.

Table 1. Individual Body Weight Changes After Consuming the MRE Ration for 30 days

Subject No.	Initial Body Weight	Final Body Weight	30 Day Weight Loss	% Weight Loss
1	181.1	176.5	−4.6	−2.5
2	162.2	157.8	−4.4	−2.7
3	177.5	173.6	−3.9	−2.2
4	138.1	145.8	+7.7	+5.6
5	180.3	172.3	−8.0	−4.4
6	201.8	193.1	−8.7	−4.3
7	170.0	159.7	−10.3	−6.1
8	176.4	167.2	−9.2	−5.2
9	161.8	155.4	−6.4	−4.0
10	148.7	145.7	−3.0	−2.0
11	199.6	190.9	−8.7	−4.4
12	159.9	152.9	−7.0	−4.4
13	154.3	152.5	−1.8	−1.2
14	197.2	194.2	−3.0	−1.5
15	147.5	155.6	+8.1	+5.5
16	151.0	145.0	−6.0	−4.0
17	163.4	164.0	+0.6	+0.4
$\bar{x}$	168.9 ± 4.6	164.8 ± 4.0	−4.0 ± 1.3	−2.2

Table 2. Individual Body Weight Changes After Consuming the RLW-30 Ration for 30 days

Subject No.	Initial Body Weight	Final Body Weight	30 Day Weight Loss	% Weight Loss
21	183.0	172.0	-11.0	-6.0
23	179.8	164.5	-15.3	-8.5
24	170.5	161.7	-8.8	-5.2
25	189.3	177.5	-11.8	-6.2
26	218.4	196.7	-21.7	-9.9
27	210.8	196.7	-14.1	-6.7
28	170.4	157.3	-13.1	-7.7
29	184.9	176.7	-8.2	-4.4
30	196.3	182.4	-13.9	-7.1
31	148.3	137.7	-10.6	-7.1
32	163.3	151.1	-12.2	-7.5
33	174.3	166.2	-8.1	-4.6
34	170.3	166.2	-4.1	-2.4
35	174.5	161.7	-12.8	-7.3
36	163.3	159.5	-3.8	-2.3
37	181.3	165.7	-15.6	-8.6
38	172.0	163.0	-9.0	-5.2
$\bar{x}$	179.5 ± 4.2	168.0 ± 3.6	-11.4 ± 1.1	-6.3

Table 3. Body Weights at the Beginning, End and in the Post Recovery Period for Twelve Members of the RLW–30 Group[1]

Subject No.	Body Weights, lbs		
	Day 1	Day 30	Day 55
23	180	165	170
24	171	162	164
25	189	178	174
26	218	197	205
28	170	157	161
31	148	138	141
33	174	166	164
34	170	166	170
35	175	162	172
36	163	160	166
37	181	166	162
38	172	163	174
$\bar{x}$	176	165	169

[1] Twelve members of the RLW–30 group were available 25 days after the end of the FTX for subsequent body weights (Day 55).

TABLE 4. Body Weights at the Beginning, End and in the Post-Recovery Period for Four Members of the RLW-30 Group.[1]

Subject No.	Body Weight, lbs		
	Day 1	Day 30	Day 85
21	183	172	172
27	211	197	200
29	185	177	179
30	196	177	183
$\bar{x}$	194	181	184

[1] Four members of the RLW-30 group were available 55 days after the end of the FTX for subsequent body weights (Day 85).

Table 5. Urine Specific Gravity and Osmolality[1]

Day	Location	Specific Gravity[2]		Osmolality (mOsm/L)	
		MRE	RLW	MRE	RLW
1	Ft.Devens	1.021 ± 0.002(1)	1.024 ± 0.001(1)	735 ± 69	896 ± 41
2	Ft. Devens	1.023 ± 0.001	1.018 ± 0.001	866 ± 51	810 ± 38
7	Camp Ethan Allen	1.025 ± 0.002(5)	1.022 ± 0.002(1)	888 ± 53	729 ± 52
14	Camp Ethan Allen	1.026 ± 0.002(7)	1.022 ± 0.002(3)	828 ± 86	758 ± 72
15	Camp Ethan Allen	1.025 ± 0.002	1.020 ± 0.002	861 ± 79	757 ± 59
21	Camp Ethan Allen	1.026 ± 0.001(6)	1.023 ± 0.002(4)	845 ± 59	688 ± 65
27	Ft. Devens	1.022 ± 0.002(2)	1.022 ± 0.002(3)	693 ± 60	695 ± 52
28	Ft. Devens	1.022 ± 0.001	1.018 ± 0.002	709 ± 60	593 ± 64
29	Ft. Devens	1.023 ± 0.001(1)	1.020 ± 0.002(2)	761 ± 53	680 ± 85

[1] Urine samples were tested by refractometer and osmometer.
The samples were first void in the morning overnight urine samples.
Values shown are $\bar{x}$ ± SEM, N=17.
There was no significant main effect due to ration for either specific gravity or osmolality.
There was a significant ($p<0.05$) main effect due to time for both of these measurements.

[2] Values in parentheses are the number of subjects testing >1.030 specific gravity.

Table 6. Twenty-four hour urine volumes, specific gravities, and osmolalities.[1]

Measurement	Ration Group	Time of Sampling		
		Day 1	Day 15	Day 30
Volume, ml	MRE	1553 ± 132	1102 ± 114	1390 ± 219
	RLW	1923 ± 154	1520 ± 676*	1677 ± 236
Specific gravity	MRE	1.019 ± 0.001	1.021 ± 0.001	1.017 ± 0.002
	RLW	1.016 ± 0.001	1.016 ± 0.002*	1.018 ± 0.002
Osmolality, mOsm/L	MRE	630 ± 51	748 ± 62	606 ± 69
	RLW	548 ± 47	525 ± 61*	605 ± 61
Fluid intake, ml[2]	MRE	-------	3021 ± 130	3113 ± 122
	RLW	-------	4028 ± 215	4962 ± 261

[1] Values shown represent the $\bar{x}$ ± SEM for 17 subjects/group.

* Significantly different, $p<0.05$ MRE vs RLW.

[2] Fluid intakes shown are the mean daily total water intake recorded during the week immediately preceding the day of the 24 hr urine collection. No water intakes were recorded prior to day 1.

Table 7. Blood hemoglobin and hematocrit values[1]

Measurement	Ration Group	Time of Sampling		
		Day 0	Day 15	Day 30
Hemoglobin	MRE	14.7 ± 0.2	15.2 ± 0.1	14.2 ± 0.2
	RLW	14.7 ± 0.2	15.3 ± 0.2	14.2 ± 0.2
Hematocrit	MRE	44.2 ± 0.7	45.5 ± 0.4	42.7 ± 0.5
	RLW	43.9 ± 0.7	45.9 ± 0.7	42.5 ± 0.7

[1] Values shown represent $\bar{x}$ ± SEM for 17 subjects/group. There were no significant main effects between rations. Within ration groups, there were no significant differences, Day 0 vs Day 30.

FIGURE LEGENDS

Figure 1. Mean weekly body weights of subjects fed MRE or RLW-30 rations for 30 days.

Figure 2. Mean cumulative body weight loss at weekly intervals for subjects fed MRE or RLW-30 rations for 30 days. The difference in body weight loss was significant ($p<0.05$) between groups at each time period. Mean 30 day weight loss was 4.0 ± 1.3 lbs/man for the MRE group and 11.4 ± 1.1 lbs/man for the RLW-30 group.

Figure 3. Daily urine dipstick ketone (acetoacetate) and specific gravity measurements for the MRE and RLW-30 groups. Ketone readings of 0-5 mg/dl=trace, 5-10 mg/dl=small.

Figure 4. Weekly urine specific gravity and osmolality in first void in the morning overnight urine samples. There was no significant main effect due to ration, however, there was a significant ($p<0.05$) main effect due to time.

RLW-30 Test, 10TH SFG

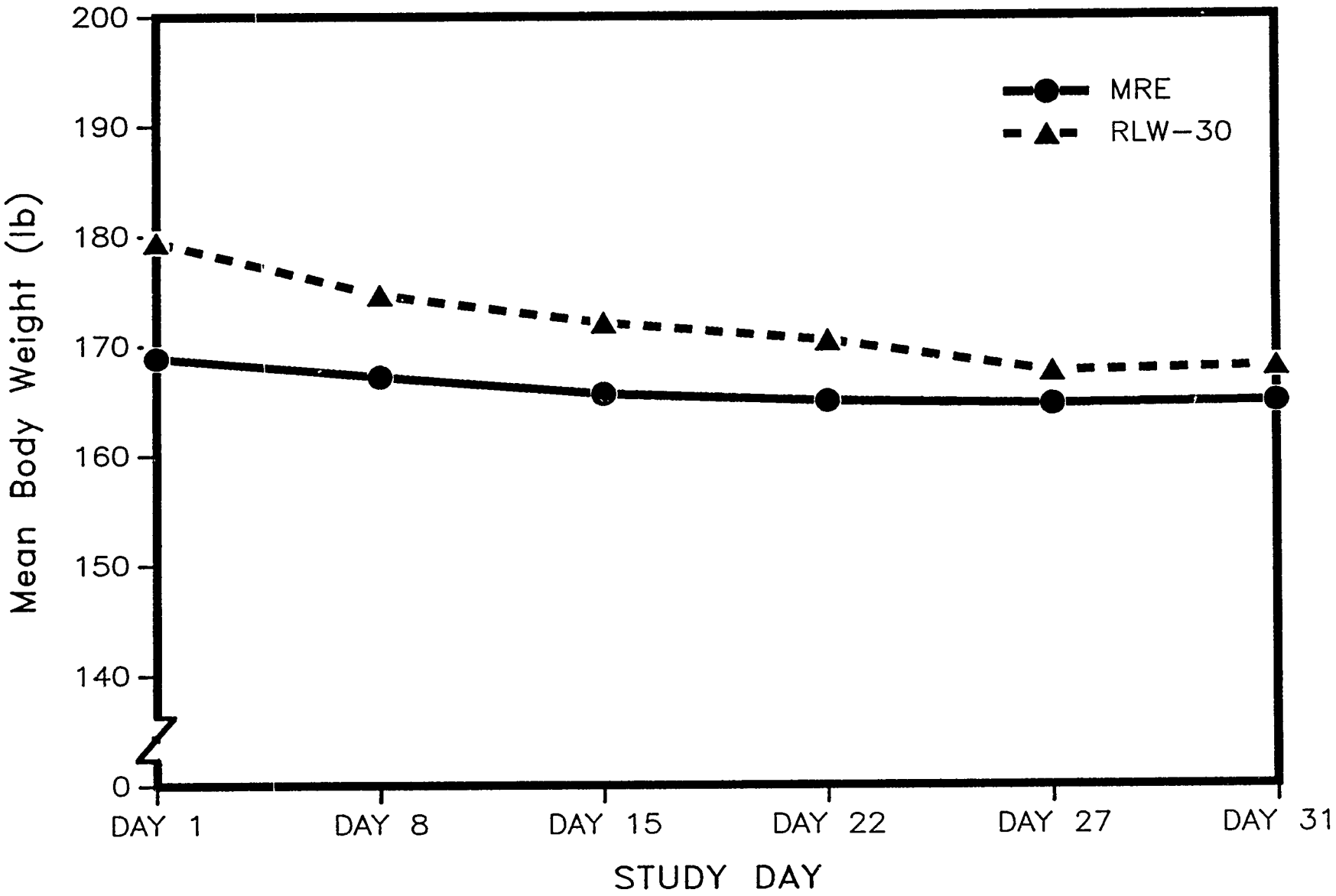


FIGURE 1

RLW-30 Test, 10TH SFG

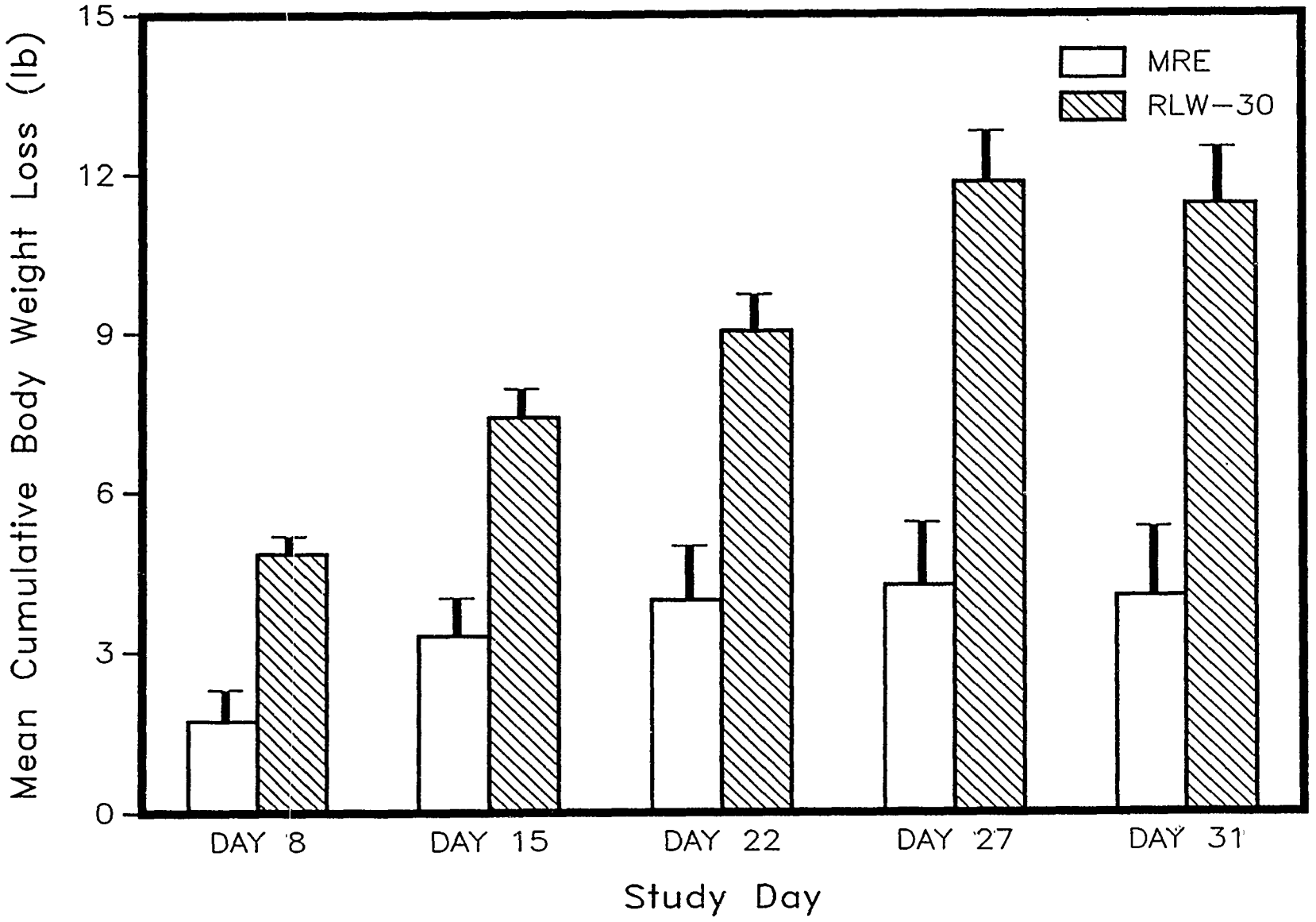


FIGURE 2

RLW-30 OT, 10TH SFG

Urine Ketones and Specific Gravity

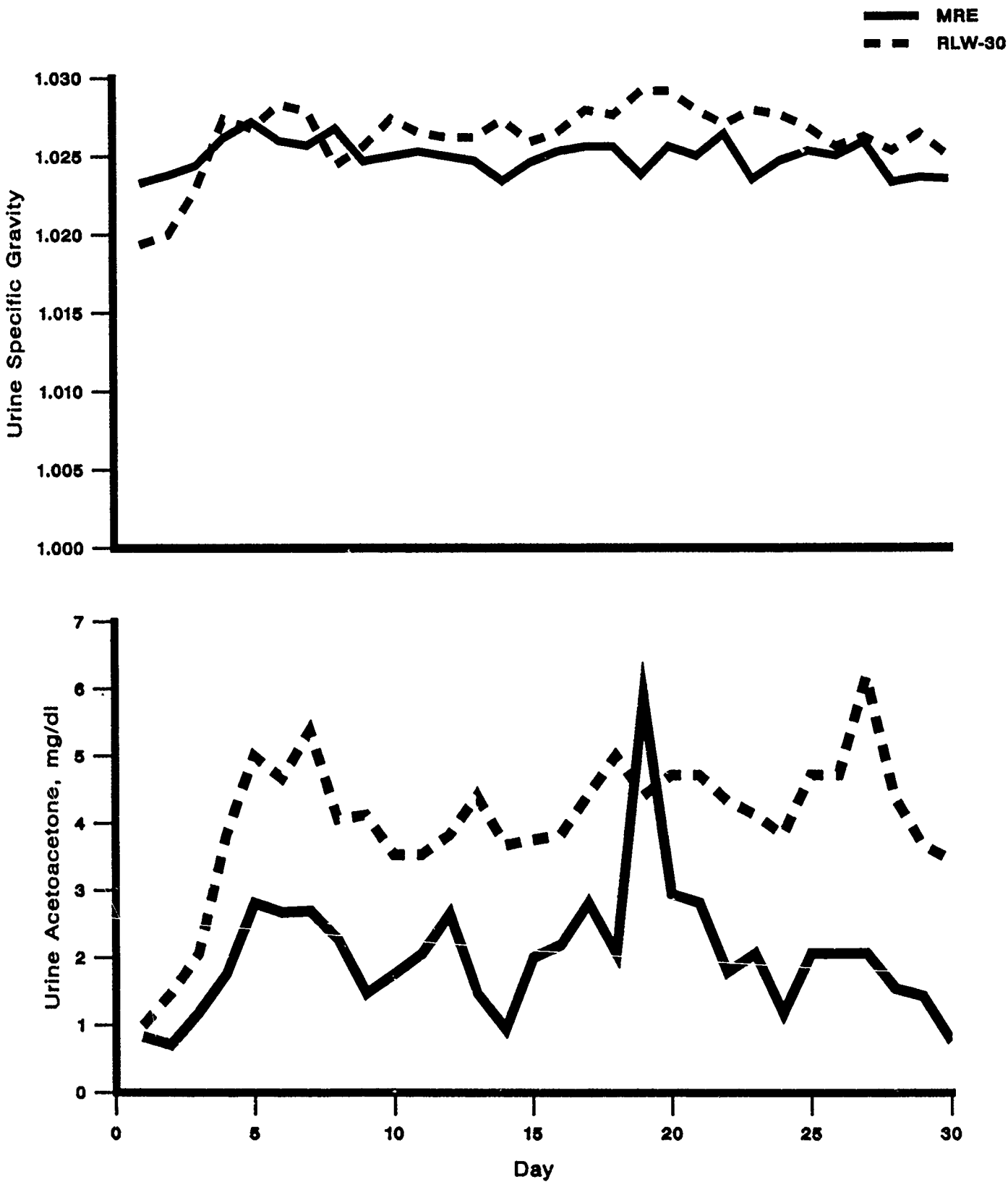


FIGURE 3

RLW-30 OT, 10TH SFG

Weekly Urine Specific Gravities and Osmolality

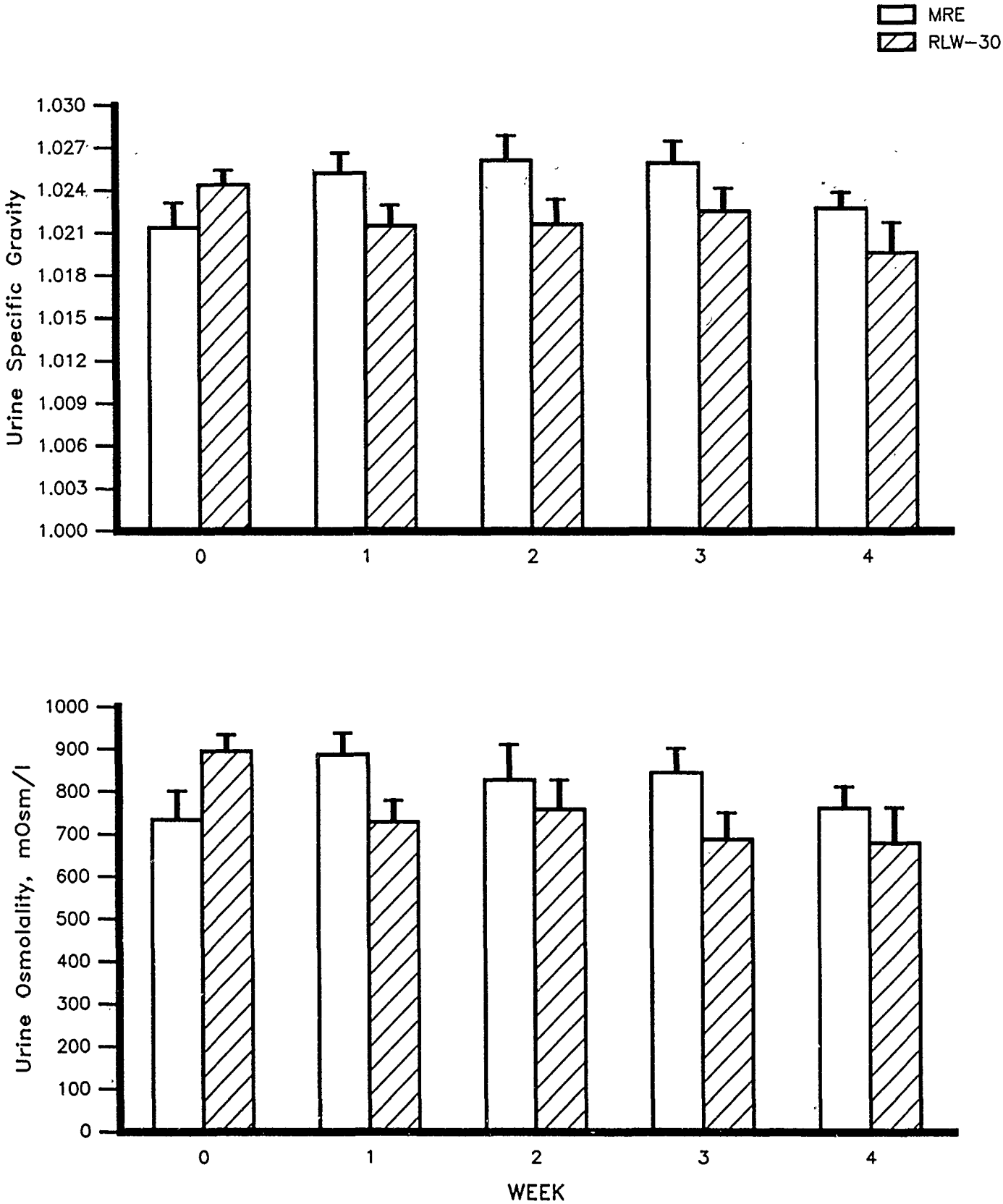


FIGURE 4

WATER INTAKES AND FLUID CONSUMPTION PATTERNS

WATER INTAKES AND FLUID CONSUMPTION PATTERNS

Methods

Data on soldiers' perceptions of fluid intake and water-related issues such as water availability and thirst were collected using a log booklet and a questionnaire. At the beginning of the field training exercise, a log booklet was distributed to each subject to record daily food and fluid intake. Subjects were briefed on the use of the booklets and were able to ask questions at the beginning and during the field exercise to clarify the use of the instrument.

The log booklets were designed to enable each subject to record all the food and water he consumed by indicating the amount of water he added to each ration item, the amount of water drunk, and the amount of each ration component consumed. A reproduction of the log booklets used by soldiers in the MRE and the RLW-30 groups may be found in Appendix 3. Similar log booklets have been used successfully in the past (1). A final questionnaire was distributed to all subjects at the end of the field training exercise. This questionnaire addressed water-related issues including water availability, thirst, pick-up water, water purification, and ration rehydration (see Appendixes 9 and 10).

Water intake was calculated by adding three sources of water: the moisture found in the ration products consumed, the water added to food and beverage products, and the water consumed by drinking. The moisture found in the ration was calculated using data provided in the menu nutrient summary provided by Food Engineering Directorate, Natick (see Appendix 1). Water intake and water added to the ration were recorded in the log booklets in terms of canteens or canteen cup measures. Recordings were converted to milliliters (ml) to standardize the three

sources of water. The canteen used by the soldiers during this test had a capacity of about 930 ml of water; the canteen cup had a capacity of about 700 ml. Water intake was analyzed using a 2-way ANOVA with repeated measures (2). Ration type was the between-subjects variable and time was the within-subject variable. Separate analyses were performed for the following dependent variables: water found in the ration, water added to the ration, water drunk, and overall water consumption.

Results and Discussion

Water Intake

Ration Effects (MRE vs RLW-30). Although the RLW-30 provided significantly less moisture than the MRE ($p<0.001$), overall water intake (including drinking, water added to the ration, and water found in the ration) was not significantly different in the RLW-30 and MRE groups ($p=0.14$). Soldiers in the RLW-30 group added significantly more water to the ration than soldiers in the MRE group ($p<0.02$), but they did not drink more water than men in the MRE group ($p=0.66$). Table 1 presents overall water intake by soldiers in both ration groups. The mean for "total water consumed" was calculated by averaging all sources of water intake for each subject each day and then averaging the subject means in each ration group. The means for each water source of water were calculated in this way, i.e., by averaging the subject means.

Soldiers in the RLW-30 group consumed the equivalent of about 4.4 liters of water/man/day, and soldiers in the MRE group consumed about 3.4 liters of water/man/day. However, because of high variability in each group, this difference was found to be not significant. See Figure 1 for an illustration of group means and SEM's. The slight trend indicating higher water consumption in the RLW-30

group supports the slight group differences observed in specific gravity and urine volume data. Although a significant difference was also not found in specific gravity and urine volume measures between groups, data indicated that soldiers in the MRE group were slightly more dehydrated at several times during the exercise and at the completion of the exercise than soldiers in the RLW–30 group. The finding that urine volumes were higher in the RLW–30 group than in the MRE group is also consistent with the water intake data.

One of the objectives of this study was to determine if the soldiers in the RLW–30 group would consume enough water to compensate for the relatively dry food found in the RLW–30. (During the 30 day exercise, the RLW provided only an average of 21 ml of water/man/day while the MRE provided an average of 366 ml of water.) Data from the log booklets indicated that soldiers in the RLW–30 group added significantly more water to the ration than was required to make up this difference between the MRE and RLW–30. In fact, the soldiers added much more water to the ration than the ration developers in Food Engineering Directorate, (FED), Natick recommended. Using the estimates from the ration developers, the average amount of water to be added to the RLW–30 would be about 740 ml/man/day. During the field test, soldiers in the RLW–30 group added an average of about 1789 ml of water to their ration each day.

Table 2 presents the average amount of water added to each RLW–30 component type (e.g., entrees, cereals, desserts). The results found in Table 2 demonstrate that soldiers in the RLW–30 group added water to some unexpected items and added significantly more water to items than recommended by FED ration developers. For example, the ration developers estimated that about 170 ml of water should be added to each entree bar to rehydrate the product; however, the soldiers

added about 500 ml of water to each entree. Apparently, most of the entree products were consumed as soups rather than as entree dishes. Observations of soldiers eating in the field support this notion. The finding that the RLW-30 group added a greater amount of water to the RLW-30 than recommended was unexpected. Because this unexpected finding could not be directly addressed during the field test, we can only suggest a possible explanation of this effect. It is quite possible that soldiers in the RLW-30 group tried to alleviate hunger sensations by filling their stomachs with water. (See sub-section on Ration Acceptance, Human Factors Assessment, and Subjective Performance Ratings for a description of hunger in both ration groups during the field exercise.) Gastric distention and the corresponding feeling of a "full stomach", have been demonstrated repeatedly as a significant discriminatory cue for satiety (3,4).

Time Effects

Statistical analysis revealed that soldiers added significantly more water to both rations as a function of time during the field exercise ($p<0.002$). The analysis also revealed a significant ration type by time interaction ($p<0.001$) indicating that this effect was different in the two ration groups. Further analyses demonstrated a slight trend indicating that soldiers in the RLW-30 group added increasingly more water to their ration as a function of time. Because of relatively high variability within the group, this trend was not found to have statistical significance. Figure 2 illustrates this trend of adding more and more water to the RLW-30 each week in the field. A similar trend was also observed for the amount of water drunk by soldiers in the field ($p=0.11$). This analysis of drinking water revealed a significant ration type by time interaction ($p<0.002$). Data suggest that the longer the RLW-30 group was in the field, the more water they drank. Again, within group variability precluded a statistically significant difference. This trend may be viewed in Figure 3.

The statistical analysis of overall water consumption revealed that there was a significant main effect of time ($p<0.05$), and that there was a significant ration type by time interaction for overall water intake (water consumption from all water sources, $p<0.001$). Results suggest that the RLW–30 but not necessarily the MRE group consumed increasingly more water (overall consumption) as a function of the length of time in the field. However, statistical significance was not found for this trend in the RLW–30 group. Figure 4 shows this trend in overall water consumption in the RLW–30 group.

Responses to post–test questionnaire

Every soldier in the MRE group and almost every soldier in the RLW–30 group stated that he picked up additional water in the field. In the MRE group, about 65% said that they used iodine tablets to disinfect pick–up water; about 50% of the RLW–30 group used iodine tablets. Those soldiers who used the disinfecting tablets waited about 30 minutes after adding the tablets before using the water for ration preparation or drinking. At least 20 minutes are required to disinfect the water before adding it to ration components that bind the iodine and render it ineffective (5).

Soldiers in both groups agreed that they almost always had enough water to rehydrate the ration items. Soldiers in the RLW–30 group indicated that they always rehydrated the entree, while soldiers in the MRE group rehydrated the entrees only about half of the time. Hot water was almost always used to rehydrate entree bars. Most of the other RLW–30 bars were rehydrated more than half the time by most soldiers. When asked about reasons for not rehydrating ration bars, the most frequently cited reason was that mixing water into the ration was too much trouble. About 12% of the RLW–30 group said that there was not enough time to rehydrate ration bars, and about 18% said that some bars tasted better dry.

Soldiers in both ration groups were able to get enough water to satisfy their thirst almost all the time. Soldiers in the MRE group reported a slightly more frequent incidence of thirst than soldiers in the RLW group. However, thirst in both groups did not appear to be a salient problem. This finding is consistent with the data on hydration status which indicated that significant dehydration was absent in both ration groups. However, the absence of thirst sensations in dehydrated soldiers in the field has been observed before (6). The finding that dehydrated individuals do not complain of thirst in a field environment emphasizes the importance of water discipline (see 7).

Conclusions

1. The 10th Special Forces Group field test provided valuable information on the amount of water intake associated with the RLW–30 and MRE rations.
2. Overall water intake was not significantly different in the two ration groups. The RLW–30 group consumed about 4.4 liters of water (l/man/day) while the MRE group consumed about 3.4 liters (l/man/day).
3. The RLW–30 group also added more water to the ration than required to compensate for the difference in moisture between the MRE and RLW–30 rations.
4. An effect of time was observed for water intake; a slight trend suggested that the RLW group consumed more water as a function of the length of time spent in the field.

REFERENCES

1. Hirsch, E., Meiselman, H., Popper, R., Smits, et al. The effects of prolonged feeding Meal, Ready-to-Eat (MRE) operational rations. Technical Report NATICK/TR-85/035, October, 1984.

2. Norvsis, M.J., SPSS/PC+: Advanced Statistics for the IMB PC/XT/AT, 1986.

3. Stunkard, A.J. Satiety is a conditioned reflex. Psychosomatic Medicine, 1975, 37, 383-387.

4. Smith, M., Pool, R., Weinberg, H. The role of bulk in the control of eating. Journal of Comparative and Physicological Psychology, 1962, 55, 115-120.

5. Rogers, M.R., Vitalian, J.J., Kaplan, A.M., and Pillion, E., Military individual and small group disinfecting systems: An assessment. Military Medicine, 1977, 141, 268-277.

6. Rogers, T.A., Setliff, J.A., Klopping, J.C., Energy cost, fluid and electrolyte balance in subarctic survival situations. Journal of Applied Physiology, 1964, 1-8.

7. Wyant, T. and Caron, P.L., Water discipline and an arctic ration prototype. Military Medicine, 1983, 148, 435-439.

Table 1. Overall water intake by soldiers in the RLW-30 and MRE groups during the 30 day field training exercise (ml/man/day).

Water Source	RLW-30 mean ± SEM	MRE mean ± SEM
Moisture in food	21 ± 1**	366 ± 12
Water added to ration	2583 ± 214*	1484 ± 78
Drinking water	1796 ± 231	1567 ± 143
Total Water Consumption	4400 ± 321	3413 ± 164

*$p<0.05$

**$p<0.01$

Table 2. Average (mean ± SEM) amount of water (ml) added to each RLW-30 component type

RATION COMPONENT	MEAN		SEM
Beverage Bars	457	±	20
Dairy Bars	117	±	10
Entree Bars	497	±	22
Cereal Bars	222	±	15
Bread Bars	70	±	10
Dessert Bars	22	±	5
Coffee, Tea, Cocoa	404	±	8

FIGURE LEGENDS

Figure 1. Mean daily water consumption for RLW–30 and MRE groups.

Figure 2. Water added to the ration as a function of time.

Figure 3. Water drunk as a function of time.

Figure 4. Total water consumed as a function of time.

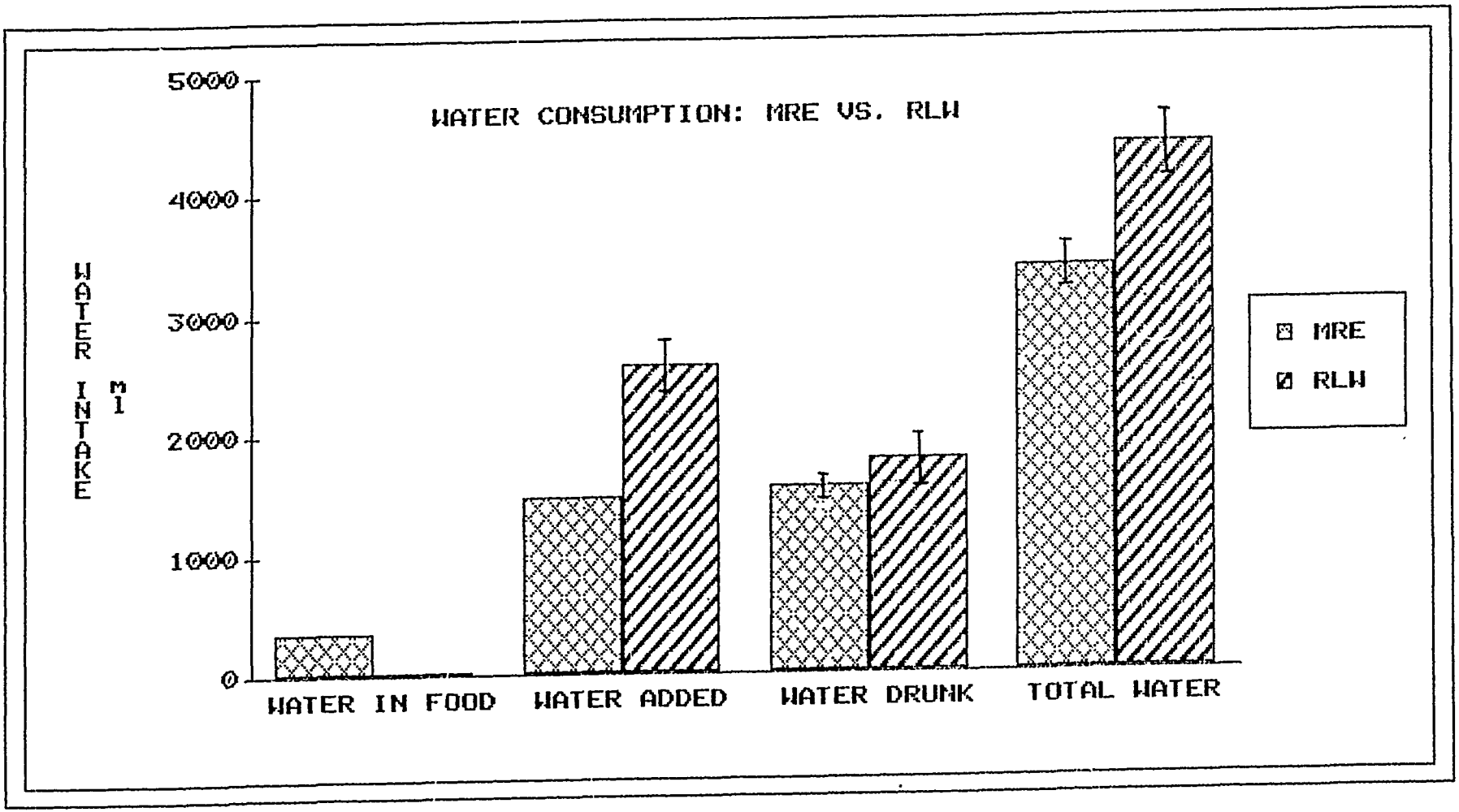

WATER CONSUMPTION: MRE VS. RLW
WATER INTAKE ml
5000
4000
3000
2000
1000
0
WATER IN FOOD
WATER ADDED
WATER DRUNK
TOTAL WATER
MRE
RLW

FIGURE 1

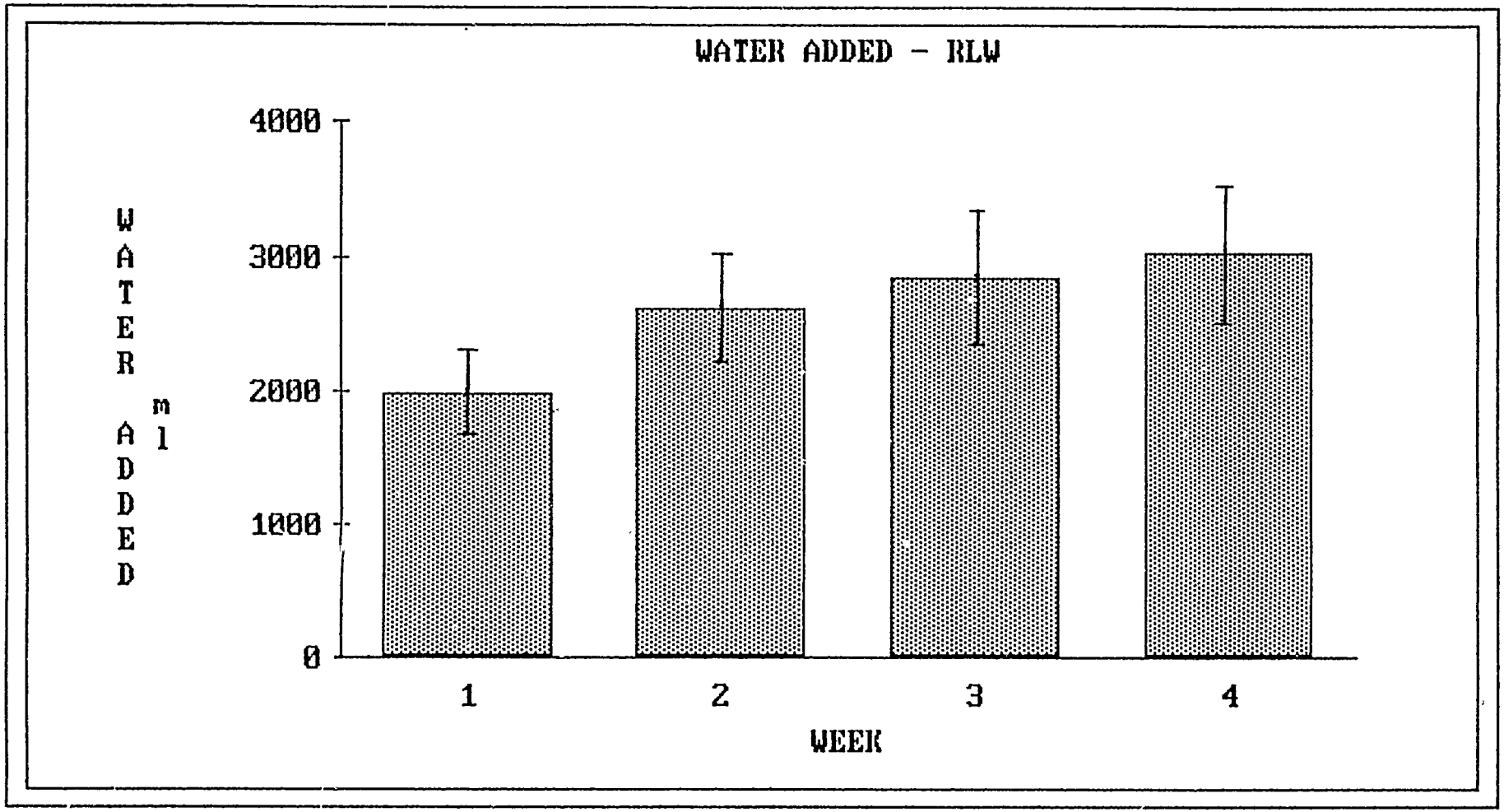

WATER ADDED - RLW
WATER ADDED ml
4000
3000
2000
1000
0
1
2
3
4
WEEK

FIGURE 2

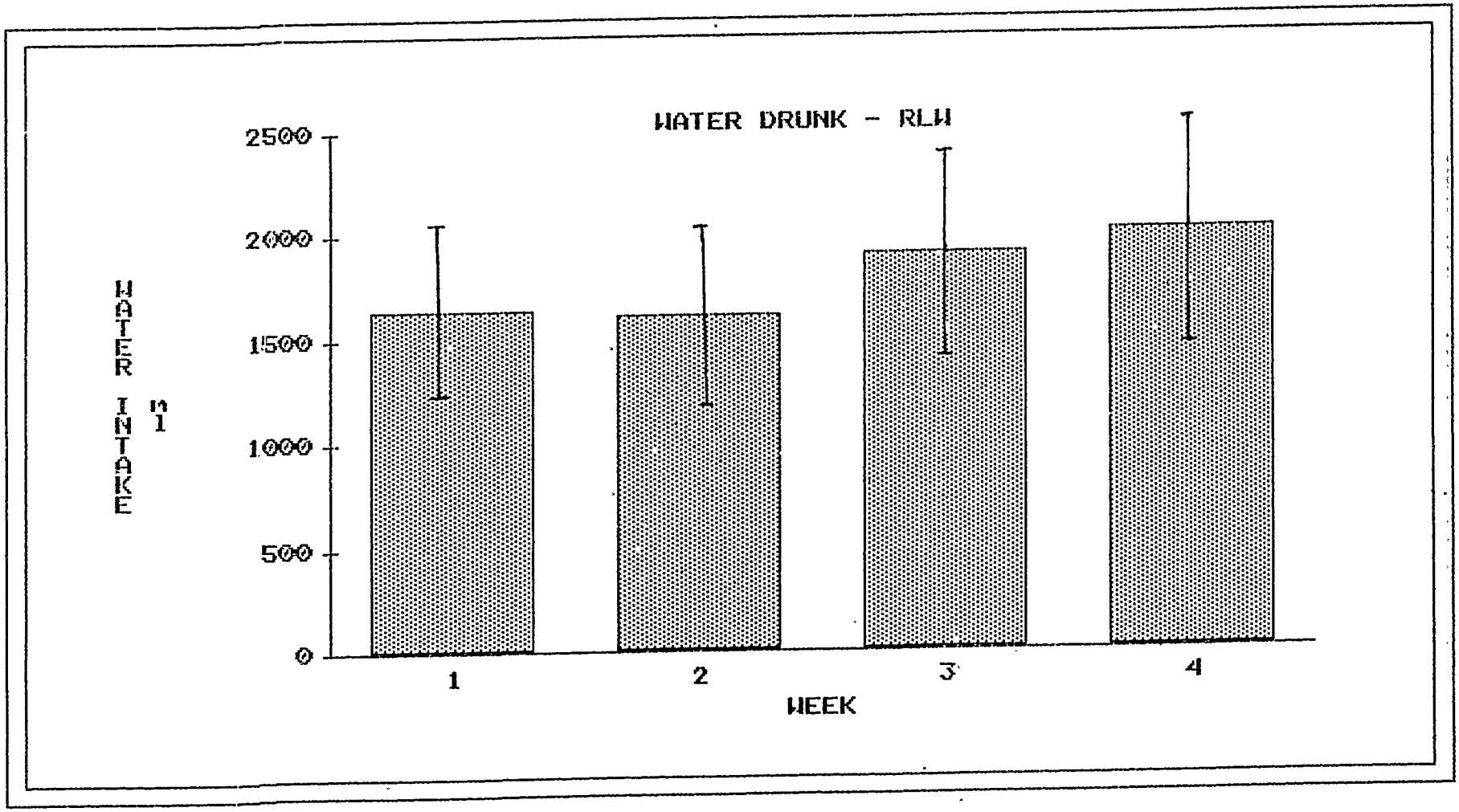

WATER DRUNK - RLH
2500
2000
1500
1000
500
0
WATER INTAKE
1
2
3
4
WEEK

FIGURE 3

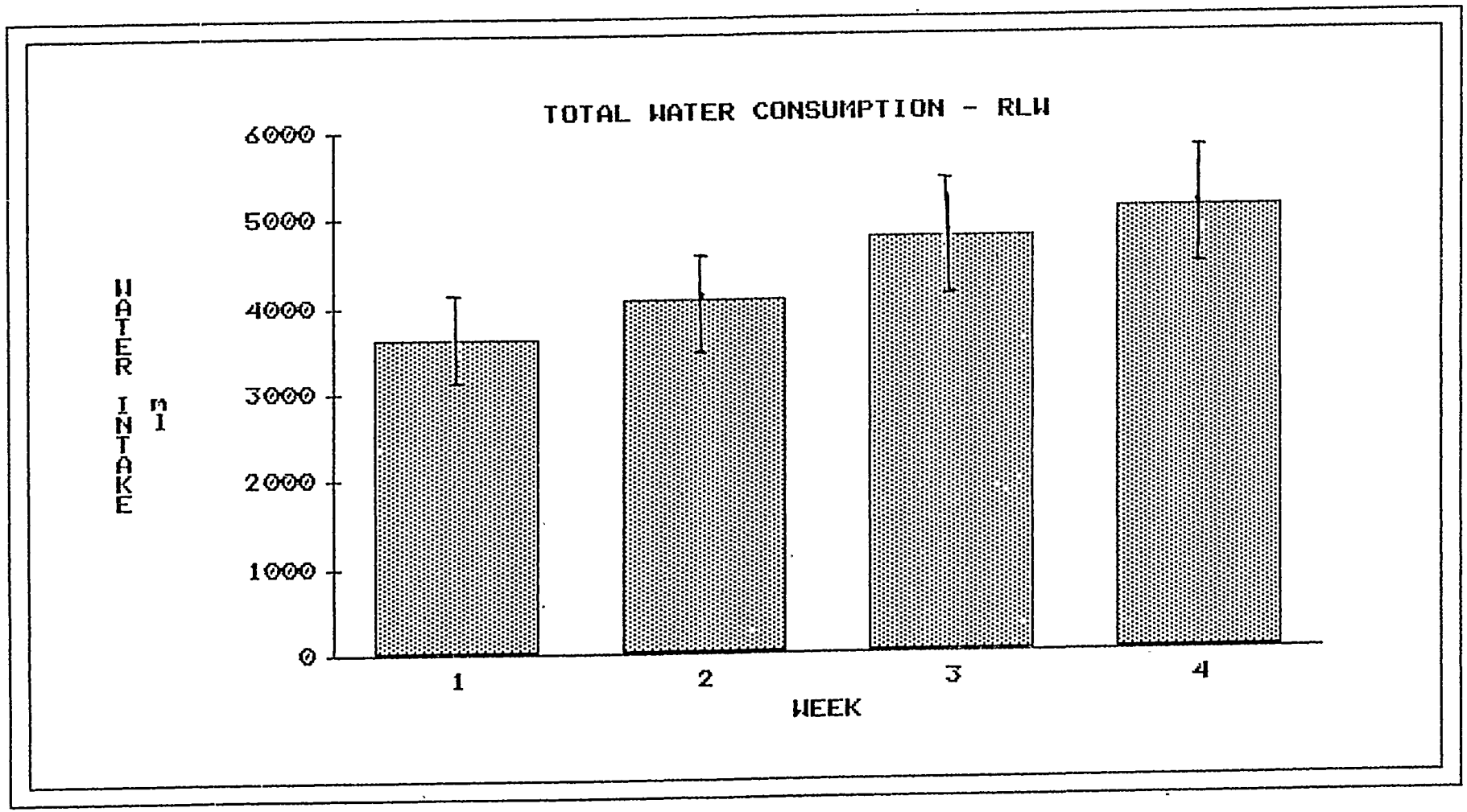

TOTAL WATER CONSUMPTION - RLW
WATER INTAKE ml
6000
5000
4000
3000
2000
1000
0
1
2
3
4
WEEK

FIGURE 4

MUSCLE STRENGTH and ENDURANCE, AEROBIC CAPACITY and BODY COMPOSITION

MUSCLE STRENGTH and ENDURANCE, AEROBIC CAPACITY and BODY COMPOSITION

Methods

Hydrostatic or underwater weighing was used to estimate the body composition of the subjects before and after the field training exercise (FTX). Subjects reported to the lab for underwater weighing in a well hydrated, fasted condition. Residual lung volume was measured just prior to underwater weighing using the closed circuit oxygen rebreathing technique described by Wilmore (1). The subject was measured in a bent over sitting position equivalent to that during underwater weighing. The procedure was repeated twice. If the difference between the two trials was greater than 150 ml, a third measure was made and the two closest values were averaged.

Following residual lung volume measurement, body weight was recorded wearing a nylon swim suit or nylon running shorts. Water temperature in the 4 x 4 x 5 foot aluminum tank was maintained between 34° and 39° C. All procedures were explained to the subject who then entered the tank. With the subject submerged to the neck, the combined seat and belt weight was determined. The weight belt was secured to the subject's waist, and he was seated in the hanging aluminum chair. The system was equipped with a snorkel apparatus to decrease the possibility of water aspiration and help those individuals who are uncomfortable in the water. Once the mouthpiece, snorkel, and noseclip were in place, the subject was asked to bend at the waist and completely submerge himself. On signal the subject inhaled then maximally exhaled. The underwater weight was determined at the end of the maximal exhalation. The subject was required to maintain his

maximal exhalation and remain motionless for about 10 seconds. On signal, the subject resumed normal breathing. The subject was given the option of remaining submerged or coming up between trials. Each subject performed 7–10 trials to obtain a reliable measure of his underwater weight. These procedures are described in greater detail by Fitzgerald et al. (2). Body density determined from underwater weight was converted into percent body fat using accepted mathematical formulae (3).

Maximal aerobic power was assessed before and after the field training exercise by direct measurement of maximal oxygen uptake using a continuous running treadmill protocol. The test began with a six minute warm up at 6 mph, 0% grade. The grade was increased by 5% at the end of six minutes, and by 2.5% every three minutes thereafter. Running speed was based on heart rate at the end of the six minute warm up according to the following schedule: <150 bpm = 7 mph; 150>170 bpm = 6.5 mph; >170 bpm = 6.0 mph (4). Subjects ran to exhaustion or until a plateau in oxygen uptake was reached. Expired air was analyzed for oxygen and carbon dioxide content using an on-line system (5). Heart rate was recorded using chest electrodes in a modified V_5 position and monitored continuously during exercise. An average of three to four–15 second samples was used to represent the subjects maximal oxygen uptake. The final heart rate was recorded during the last minute of exercise.

Isometric handgrip strength was measured before, after and at three points during the FTX. A field portable adjustable handgrip dynamometer was used. Subjects squeezed the device maximally with their right hand while in a standing position. A mean of the three trials was used as the final score.

Isokinetic leg extension strength and endurance measurements were made on a Cybex II isokinetic dynamometer at 30^{0} and 180^{0}/sec. The dynamometer controls the velocity of the contraction while measuring torque produced through 90^{0} of motion. The subject was seated in a well padded chair with restraining straps over his thighs and waist. His right leg was connected at the ankle to the Cybex lever arm by a padded cuff. On command the subject was asked to extend his leg as forcefully as possible through a full range of motion. A mean of the two highest of three trials was used as the final score. The endurance measurement, described by Thorstensson (6) consists of 50 maximum contractions over a 60 sec period at 180^{0}/sec. The percent decrease in the average torque of the first four to the last four contractions serves as an index of fatigue. Also reported are the highest peak torque; the average of the first four contractions, and the mean peak torque; the average of all 50 contractions.

Immediately before entering the field, and on the final day of the study all subjects completed a standard Army physical training test (PT test) consisting of timed push ups and sit ups. A 10 km road march with a 60 pound pack replaced the usual two mile run test.

Subjects were tested over a three day period on only one station each day. Pre and post FTX ration testing was done in the same order for each test subject.

Results and Discussion

The results of hydrostatic weighing are presented in Table 1. It should be noted that the body weight changes reported in this table are not of the same magnitude as those reported in other sections of this report. The reason for this discrepancy is that the weights were not measured at the same time and varied by

as much as 8 days pre-FTX weight and 3 days post-FTX weight. Several subjects reported overeating just prior to the start of the FTX as a self defensive measure, and this may explain some of the difference in body weight change. The body weights reported in Table 1 were those taken just prior to hydrostatic weighing.

There were no significant group differences in any of the body composition variables as revealed by two-way analysis of variance. The MRE group lost 1.5 kg while the RLW-30 group lost 2.5 kg of body fat. Post hoc examination of the significant interaction effect showed that the RLW group was significantly fatter pre-FTX, but had the same amount of body fat as the MRE group post-FTX.

A significant interaction effect was also obtained from a two way analysis of variance of fat free mass. The RLW-30 group had significantly more fat free mass (2.9 kg) than the MRE group at the initial hydrostatic weighing. The MRE group was not significantly different from pre to post-FTX testing, and was not significantly different from the RLW-30 group after the FTX. The fat free mass of the RLW-30 group decreased significantly by 2.3% or 1.5 kg during the FTX. It was expected that the subjects with the lowest percent body fat would lose the greatest amount of lean body mass. Visual comparison of the data obtained from the leanest and fattest subject, as well as the subject who lost the most weight does not bear this out, as shown in Table 2. A loss of 1.5 kg fat free mass during a moderately active 25 day training period should be considered significant. Had these soldiers been required to expend more calories on a daily basis, they may have begun to show serious performance changes due to loss of muscle tissue. It has been previously reported that individuals who lose a significant amount of weight while consuming the MRE lose two thirds from body fat stores and one

third from fat free mass (7). The RLW–30 group, while smaller in size, seems to follow this pattern, as 37% of the 4.0 kg body weight loss was fat free mass and 63% was body fat. RLW–30 failed to meet test issue 2.1.2, as the 1.5 kg loss of fat free mass represents 37% of the total decrease in body mass. While no significant overall group effect was found, this problem needs to be examined under more controlled conditions, where the caloric expenditure can be closely monitored.

Table 3 lists the mean, standard error of the mean and percent change for all variables measured during the maximal oxygen uptake test. The absolute maximal oxygen uptake ($l \cdot min^{-1}$) decreased in both groups from pre to post–FTX, however there was no significant difference between groups before or after the FTX. Heart rate at maximal oxygen uptake did not change following the FTX. Minute ventilation measured at maximal oxygen uptake was higher in the RLW–30 group prior to the FTX, but both groups dropped to an equivalent level upon return from the field. As none of the measurements made during the maximum oxygen uptake test demonstrated any significant group effect based on a two way analysis of variance, the changes that occurred cannot be attributed to differences in diet. Most of the observed differences are probably due to a detraining effect. Many of the special forces soldiers are marathoners and triathletes, and most spend a good deal of their time in physical training, particularly running. It has been demonstrated that the maximal oxygen uptake of highly trained athletes is negatively affected after only two weeks of detraining (8). This detraining is supported by the increased respiratory quotient and subjective perception of greater difficulty on the part of the subjects during the second maximal oxygen uptake test.

When maximal oxygen uptake was considered relative to body weight ($ml \cdot kg \cdot min^{-1}$) both groups showed a significant decrease over time. Post hoc

analysis revealed that while the aerobic capacity of both groups declined, the MRE group had a significantly higher relative maximal oxygen uptake at the end of the FTX than the RLW-30 group. This may be due to group differences in loss of body weight. The MRE group lost a significant amount of body fat, but had no change in fat free mass. The RLW-30 group also finished with a significantly lower body fat, but they had a significant loss of fat free mass. The MRE group lost metabolically inactive tissue, and was therefore better able to maintain relative aerobic capacity ($\dot{V}O_2$ in $ml \cdot kg \cdot min^{-1}$) although there was a loss of absolute aerobic capacity ($\dot{V}O_2$ in $L \cdot min^{-1}$). The RLW-30 group lost metabolically active tissue as well as body fat and could not preserve their relative maximal oxygen uptake in the face of detraining as well as the MRE group.

The effects of detraining are generally in inverse relation to the soldier's state of training. In order to determine whether soldiers with a high aerobic fitness experienced a greater decrease in maximal aerobic capacity from pre to post-FTX, the soldiers were divided into two fitness groups within each ration group. Soldiers whose maximal oxygen uptake was less than or equal to 55 $ml \cdot kg \cdot min^{-1}$ made up the lower fitness group, and those with greater than 55 $ml \cdot kg \cdot min^{-1}$ were designated as the higher fitness group. This break point was arbitrarily selected to yield two groups of similar size within each ration group. There was no significant difference in the change in aerobic capacity from pre to post-FTX between high and low fitness groups consuming the RLW-30. In the MRE group, the highly fit test subjects lost a significantly ($p<0.05$) greater amount of aerobic fitness (both absolute and relative) from pre to post-FTX. Since the MRE group consumed a calorically adequate diet, it appears that detraining plays a greater role in the loss of aerobic capacity than does diet during a prolonged field training exercise.

The isometric handgrip strength of both groups measured before, during and after the FTX are shown in Table 4. There was no significant difference between groups. Post hoc analysis of the significant interaction term revealed that the RLW-30 group was significantly greater than the MRE group during the FTX-1 measurement. There was no significant difference in handgrip strength between groups at pre and post-FTX measurements. The differences found in handgrip strength are of small magnitude and little practical importance.

Isokinetic strength and endurance before and after the FTX for both groups are presented in Table 5. Two way analysis of variance revealed significant group, repeated measures and interaction effects for isokinetic strength at 30 and 180 ^{0}/sec. The group and repeated measures effects were not supported by post hoc analysis at either speed. Analysis of the interaction effect at 30 ^{0}/sec revealed that the MRE group scored significantly lower than the RLW-30 group at both measurements. While the MRE group maintained isokinetic strength at 30 ^{0}/sec, the RLW-30 group lost a significant amount of isokinetic strength pre to post-FTX. At the higher speed, the RLW-30 group was significantly stronger than the MRE group before the FTX, but was not significantly different at the post measurement. The RLW-30 group showed a small, non-significant strength loss at 180 ^{0}/sec, while the MRE group had a significant increase in strength. The MRE group fared better than the RLW-30 group in maintenance of isokinetic strength, particularly at 30 ^{0}/sec.

The results of the isokinetic endurance test paralleled those of isokinetic strength at 180 ^{0}/sec. The highest peak torque and mean peak torque of the MRE group was lower than the RLW-30 group at the pre-FTX measurement, but improved significantly post-FTX. The RLW-30 group did not change and was

equivalent to the MRE group post-FTX. There were no effects of any kind in peak torque decrease.

The results of the PT test must be viewed with some skepticism, particularly the rucksack march results. Review of the individual pre and post-FTX scores shows that the pack march time was much longer for some individuals on the final test day. No incentive was provided to ensure that the soldiers performed at top speed, and quite often they did not. Final heart rates as low as 102 beats per minute substantiated this observation. Several groups of soldiers walked together and finished with identical times on both tests. With these problems in mind, the PT test means and standard errors for the two ration groups are shown in Table 6. No significant differences were found between groups on any of the PT test measurements.

Upon review of some of the results of this study a question of concern was whether the RLW-30 could be used by highly fit soldiers with a low percent body fat. In an attempt to answer this question, the RLW-30 group was divided into 4 groups based on percent body fat (≤10%, 11-15%, 16-20% and >20%). A one way analysis of variance of selected body composition and performance measure changes from pre to post-FTX did not reveal any differences between the groups. While only one soldier with a body fat of less than 10% completed the study, the other groups do not demonstrate a trend toward better performance by those with greater initial percent body fat. These data are illustrated for the RLW-30 group in Table 7.

Conclusions

1. The RLW-30 diet resulted in a significant decrease in fat free mass of

1.5 kg. A continued loss of fat free mass at this rate could begin to seriously affect performance if the caloric deficit were maintained.

2. The RLW–30 group was not able to maintain their relative maximal oxygen uptake ($ml \cdot kg \cdot min^{-1}$) during the FTX as compared to the MRE group. This may be due to a significantly greater loss of fat free mass as a proportion of total body weight lost in the RLW–30 group.
3. The MRE group was better able to maintain and in some instances increase their isokinetic strength than the RLW–30 group.
4. The RLW–30 did not appear to have a greater detrimental effect on the performance of highly fit individuals, defined as those with a higher maximal oxygen uptake, or those with lower percent body fat.

REFERENCES

1. Wilmore, J.H. A simplified method for determination of residual lung volumes. Journal of Applied Physiology, 27:96–100, 1969.

2. Fitzgerald, P.I., J.A. Vogel, W.L. Daniels, J.E. Dziados, M.A. Teves, R.P. Mello and P.J. Reich. The body composition project: A summary report and descriptive data. USARIEM Technical Report No T5/87, 1987.

3. Siri, W.E. Body composition from fluid spaces and density. Berkeley, Donner Lab Med Physics, University of California Report, 1956.

4. Maksud, M.G. and K.D. Coutts. Comparison of a continuous and discontinuous graded treadmill test for maximal oxygen uptake. Medicine and Science in Sports and Exercise, 3:63–65, 1971.

5. Cote, M.G., D.M. White, R.P. Mello, D.S. Sharp and J.F. Patton. Development and assessment of an on–line aerobic measurement system. USARIEM Technical Report No T1/79, 1978.

6. Thorstensson, A. Muscle strength, fiber types and enzyme activities in man. Acta Physiologica Scandinavica, Supplementum 443, 1976.

7. Teves, M.A. and J.A. Vogel. Body composition and muscle performance aspects of the 1985 CFFS test. USARIEM Technical Report No T12/86, 1986.

8. Coyle, E.F., W.H. Martin III, D.R. Sinacore, M.J. Joyner, J.M. Hagberg and J.O. Holloszy. Time course of loss of adaptations after stopping prolonged intense endurance training. Journal of Applied Physiology: Respiration, Environment and Exercise Physiology, 57(6): 1857–1864, 1984.

Table 1. Body Composition Before and After Ration Consumption Based on Hydrostatic Weighing (mean and SEM)

Change	Meal Ready to Eat Pre-FTX	Post-FTX	% Change	Ration Light Weight 30 Days Pre-FTX	Post-FTX	%
	n=17			n=17		
Percent Body Fat	15.6 0.8	13.9 1.0	-10.9	16.5 0.8	13.9 0.7	-15.7
Fat Free Mass (kg)	62.9 1.0	63.1 1.9	0.3	65.8 0.9	64.3 0.8	- 2.3
Body Fat (kg)	11.9 1.0	10.4 0.9	-12.6	13.2 1.0	10.6 0.8	-19.7
Body Mass (kg)	74.8 2.10	73.6 1.76	- 1.6	79.3 1.80	75.3 1.57	- 5.0

/c2

Table 2. Changes in the Body Composition of Selected Individuals in the RLW-30 Group Compared to the Group Mean.

Test Subject	n		Body Mass (kg)	Percent Body Fat	Body Fat (kg)	Fat Free Mass (kg)
Leanest	1	Pre	76.2	9.1	6.9	68.9
		Post	73.8	6.8	5.0	68.3
		Δ	−2.4	−2.3	−1.9	−0.6
Fattest	1	Pre	77.0	25.0	18.7	58.3
		Post	73.2	20.5	14.8	58.4
		Δ	−3.8	−4.5	−3.9	0.1
Greatest Weight Loss	1	Pre	95.6	20.2	19.3	76.3
		Post	88.0	15.3	13.5	74.5
		Δ	−7.6	−4.9	−5.8	−1.8
Group Mean	17	Pre	79.3	16.5	13.2	65.8
		Post	75.3	13.9	10.6	64.3
		Δ	−4.0	−2.6	−2.6	−1.5

Table 3. Physiological Measurements Collected During Maximal Treadmill Exercise Before and After Ration Consumption (Mean and SEM)

Change	Meal Ready to Eat Pre-FTX	Post-FTX	% Change	Ration Light Weight 30 Days Pre-FTX	Post-FTX	%
	n=17			n=16		
VO2 ($l \cdot min^{-1}$)	4.23 0.11	3.80 0.09	−10.2	4.31 0.08	3.67 0.07	−14.8
VO2 ($ml \cdot kg \cdot min^{-1}$)	56.2 1.3	51.7 1.2	−8.0	53.8 1.2	48.3 1.2	−10.2
Heart Rate (bpm)	191.0 2.2	196.0 1.6	2.6	196.0 2.5	196.0 1.0	0.0
VE_{BTPS} ($l \cdot min^{-1}$)	151.7 5.9	139.6 4.9	−8.0	160.5 2.6	139.1 3.5	−13.3
R	1.10 0.07	1.19 0.02	−8.2	1.03 0.01	1.16 0.02	12.6

Table 4. Isometric Handgrip Strength (kg) Measured Pre-FTX, at Each Field Measurement and Post-FTX

	Meal Ready to Eat (Mean ± SEM, n=17)	Ration Light Weight 30 Days (Mean ± SEM, n=16)
Pre-FTX	50.0 ± 1.6	52.6 ± 2.2
FTX 1	50.9 ± 1.7	57.5 ± 2.1
FTX 2	51.2 ± 1.9	55.6 ± 2.0
FTX 3	51.5 ± 7.4	53.1 ± 9.0
Post-FTX	53.1 ± 1.9	55.2 ± 2.0

Table 5. Isokinetic Muscle Strength and Endurance Before and After Ration Consumption (Mean and SEM)

	Pre-FTX	Post-FTX	% Change	Pre-FTX	Post-FTX	%change
Strength		n=17			n=17	
30°/sec	218.0	220.9	1.3	263.2	242.3	-7.9
(Nm)	35.2	30.1		39.6	37.3	
180°/sec	140.2	152.4	8.7	165.3	160.8	-2.7
(Nm)	20.5	20.0		20.9	21.0	
Thorstensson		n=15			n=16	
Highest Peak	136.5	151.7	11.1	160.7	160.4	-0.2
Torque (Nm)	19.5	20.8		21.3	19.9	
Mean Peak	92.7	102.6	10.7	104.3	102.4	-1.8
Torque (Nm)	13.0	15.7		15.1	14.3	
Percent Torque	54.3	53.9	-0.7	61.8	59.9	-3.1
Decrease (%)	12.3	12.8		6.4	9.5	

Table 6. Physical Training Test Results For Each Group Before and After the Field Training Exercise (Mean and SEM, n=17)

	Meal Ready to Eat			Ration Light Weight 30-Days		
	Pre-FTX	Post-FTX	%Change	Pre-FTX	Post-FTX	% Change
Pushup	77.9	72.6	-6.8	75.4	69.4	-7.9
	3.2	3.3		3.4	3.9	
Situp	70.3	69.5	-1.1	73.0	71.2	-2.5
	2.5	2.8		2.7	2.9	
10Km Pack	85.1	96.2	13.0	92.9*	87.6*	-5.7
March(min)[1]	2.8	2.9		3.2	2.0	

*n=15 Two subjects were unable to participate due to orthopedic problems.

[1] Note that a decrease in time to complete the 10 km pack march represents an improvement, whereas a decrease in number of pushups or situps does not represent an improvement.

Table 7. Performance and Body Composition Changes in the RLW-30 Group as a Function of Percent Body Fat.

		≤ 10% (n=1)	11-15% (n=8)[1]	16-20% (n=3)	> 20% (n=5)
VO2 ($l \cdot min^{-1}$)	Pre	4.57	4.31	4.14	4.37
	Post	3.82	3.72	3.43	3.72
	Δ	-.75	-.59	-.71	-.66
VO2 ($ml \cdot kg \cdot min^{-1}$)	Pre	58.4	56.2	51.2	51.0
	Post	51.7	51.1	44.6	45.8
	Δ	-6.7	-5.1	-6.6	-5.2
Isokinetic Leg Strength $30^{o} \cdot sec^{-1}$	Pre	308.0	254.0	291.0	252.0
	Post	289.0	233.0	262.0	235.0
	Δ	-19.0	-21.0	-28.0	-16.0
$180^{o} \cdot sec^{-1}$	Pre	200.0	154.0	172.0	171.0
	Post	190.0	151.0	173.0	163.0
	Δ	-10.0	-3.0	+1.0	-9.0
Fat Free Mass (kg)	Pre	68.9	64.7	65.5	67.0
	Post	68.3	63.4	63.5	65.3
	Δ	-0.6	-1.3	-2.0	-1.7
Body Fat (kg)	Pre	7.3	10.3	14.4	18.2
	Post	5.5	8.4	12.5	14.2
	Δ	-1.8	-1.9	-1.9	-4.0

SELF-REPORTED SYMPTOMS, MOOD STATES, AND PERFORMANCE ATTRIBUTES AND OBJECTIVE PERFORMANCE MEASURES

SELF-REPORTED SYMPTOMS, MOOD STATES, AND PERFORMANCE ATTRIBUTES AND OBJECTIVE PERFORMANCE MEASURES

Methods

Test Materials and Apparatus

Self-report measures. Three questionnaires were administered to determine whether there were personality differences between the two groups that could influence the outcome of the test. 1. Beck Depression Inventory (BDI) (1). Twenty-one sets of graded statements related to overt signs of depression were presented. A forced-choice format required the subject to select the one statement in each set that best described him. 2. Spielberger Trait Anxiety Scale (TAS) (2). Twenty statements related to individual differences in response to threatening situations were presented. Each statement was rated on a four-point scale according to how well it generally described the subject. 3. Rotter Internal-External Locus of Control Scale (LOC) (3). Twenty-three pairs of statements were presented in a forced-choice format. Each statement reflected either a fatalistic point of view or the belief that an individual has control over events in his life. Six filler pairs were also included. The questionnaire was scored with reference to the degree of perceived external control.

Three broad-based questionnaires were administered for a comprehensive assessment of changes resulting from test conditions (4). 1. Environmental Symptoms Questionnaire (ESQ) (5). Sixty-eight items were presented, most of which described physical states. The intensity of each item was rated on a six-point scale. 2. Profile of Mood States (POMS) (6). Sixty-four items related to tension, anger, depression, confusion, fatigue, and vigor were presented. The intensity of each item was rated on a five-point scale. 3. Military Abilities

Questionnaire (MAQ) (4). Ninety items related to attributes of military performance were presented. Thirty items were based on physical, psychomotor, and cognitive abilities. Sixty items were based on behaviors critical to mission performance. These included aspects of individual performance, unit interaction, function within the military hierarchy, and interaction with civilians. Difficulty was rated on one of two mutually-exclusive five-point scales. One scale was used if the rating was based on direct observation. The other provided an estimate of expected difficulty in cases where direct observation was not possible. The information obtained from all three questionnaires was retrospective, encompassing the entire previous week.

All questionnaires were programmed on portable computers (GRiD Compass II, GRiD Systems Corporation, Mountain View, CA). Instructions preceded each questionnaire. Individual items (accompanied by the appropriate rating scale) or sets of forced-choice statements appeared on the screen one at a time. No items could be omitted, and out-of-range responses were not accepted.

Objective performance tests. Two reaction time tests, previously shown to be sensitive to nutritional variables (7,8), were administered to assess psychomotor performance. Both tests were programmed on the GRiD computers. 1. Simple reaction time. A visual cue was presented in the center of the computer display, and the subject was instructed to respond as quickly as possible using the space bar. Three hundred trials were presented. 2. Four-choice reaction time. This task resembles the Wilkinson Four-Choice Reaction Time Test and is a measure of vigilance. A constant and a variable visual cue, which randomly appeared in one of four locations, were presented on the display. The subject was instructed to respond as quickly as possible but was also required to accurately indicate the location of the variable cue. This was accomplished by pressing one of four adjacent cursor keys.

Five hundred trials were presented. Response latency in milliseconds was automatically recorded. Errors of commission (responding before the stimulus appears) and errors of omission (response latency>1 sec.) were also recorded to assure that the subjects were responding as instructed.

Cognitive performance was assessed using a new procedure developed for this test. Levitsky and Strupp (9) have stressed the distinction between cognitive ability as measured under laboratory conditions and the spontaneous mental activity that is required in natural settings. Even under the most extreme conditions of undernutrition studied to date, few deficits in cognitive test performance were observed (10). However, apathy and decrements in "self-initiated mental activities" were pervasive. Therefore, standard cognitive tests were modified for the purposes of this test to allow measurement of both numerical-spatial performance and its initiation and persistence. Four different sets of computer-generated test booklets, printed on a laser copier, were used. Each booklet was designed to be carried in the field for a week at a time. The format was reduced to 50% the original, allowing compression of a large number of problems into a booklet small enough to fit in a Battle Dress Uniform (BDU) pocket. Soldiers were instructed to carry the booklets with them throughout the FTX and work on the problems during their free time. Date and time were to be entered whenever work was initiated and terminated. Both accuracy and output were stressed.

Each booklet contained two types of problems previously shown to be sensitive to nutritional variables (10,11). 1. Arithmetic. A total of 3600 problems requiring addition of three two-digit numbers were presented. 2. Map-Compass problems. Five hundred and forty problems requiring an understanding of the relationship between compass readings and direction, grid coordinates and distance, and various

spatial concepts were presented. Groups of arithmetic problems alternated with a smaller number of map-compass problems. The same problems were included in each of the four booklets, but the order varied.

Procedure

Pre-test sessions. All sessions were conducted under laboratory conditions at USARIEM and scheduled in conjunction with physiological testing (see above). Training, personality testing, and baseline measurement of parameters to be studied during the test were accomplished in small groups during two types of sessions. 1. Test booklet training. Each soldier was given 45 minutes of instruction and practice. No baseline measures were obtained since the test booklets were designed to be used over the course of a week and required self-initiation. 2. Computer testing. Two-hour sessions were held, during which all subjective and objective tests programmed on the GRiD computers were administered. Soldiers were familiarized with the computers. The personality tests (BDI, TAS, and LOC) were administered on a one-time basis. Baseline measures for the other self-report measures (ESQ, POMS, and MAQ) were then obtained. Before and after the questionnaires were administered, sets of practice trials for reaction time tests (300 trials each for simple, 500 each for four-choice) were given. Baseline reaction times were obtained following the last practice set.

Test sessions. Three of the four test sessions were held in an unheated GP-Medium tent at the base camp in Vermont. The fourth session was conducted under laboratory conditions at USARIEM. Soldiers were assigned to their respective rations for the entire four-week test period. Four groups of soldiers were tested separately in sessions lasting approximately 45 minutes. Symptom (ESQ), mood (POMS), and performance difficulty (MAQ) ratings were obtained first. Then,

mood (POMS), and performance difficulty (MAQ) ratings were obtained first. Then, reaction time (simple and four-choice) tests were administered. During these sessions, the test booklets carried in the field over the previous week were turned in, and new booklets were issued.

Data analysis. In most cases, data from all subjects (N=36) were included. These data were typically submitted to two levels of statistical analysis. 1. Two-way repeated-measures analysis of variance (ANOVA). Data were first analyzed to determine whether there were overall differences between the two groups, overall differences over time for both groups, and any interaction between group and time effects. 2. Post hoc tests (Newman-Keuls). For measures showing significant ($p<0.05$) ANOVA main effects and interactions, differences were more precisely specified. Comparisons were made of all possible combinations of between-group and within-group mean values. Exceptions to this general procedure are noted as they occur.

Results

Self-report Measures

Personality traits. No significant pre-test group differences were found in measures of depression (BDI), anxiety (TAS), and locus of control (LOC). Table 1 shows mean values and variability.

Symptoms (ESQ). Overall, there was a significant ($p<0.0001$) change in the total symptom score over time. This was due primarily to changes occurring for the RLW-30 group. Table 2 shows that total score for the RLW-30 group increased significantly above baseline (pre-test) in the first test week and remained significantly elevated throughout the test while no significant increases occurred for the MRE

group. The largest increase for the RLW–30 group occurred in the third test week, when the total score was 146% above baseline. A significant difference between the two groups occurred only at that point. There was no significant overall difference between the two groups. Figure 2 shows the pattern of change. Baseline values are identical for the two groups. During the four test weeks, the curve for the RLW–30 group shows a sharp peak during the third test week. The curve for the MRE group remains flat throughout the test.

When the symptoms that comprise the total score were analyzed individually, significant overall differences were seen over time (Appendix 6), between groups (Table 3), and in the general pattern of change shown by the two groups (Table 4). Most of the significant group differences seen during specific test weeks occurred for the symptoms presented in Tables 3 and 4. As with total score, these differences were most apparent during the third test week. However, significant differences were seen as early as the first test week ("dim vision", "hunger", "increased urination", and "sweatiness") and as late as the fourth test week ("hunger", "increased urination", and "feverishness"). In all cases, the RLW–30 group reported greater symptom intensity than did the MRE group. This elevated level of symptomatology could not be attributed to pre–existing differences, since there were no significant baseline differences in any of the individual symptoms. Pre–test values, however, did contribute to the difference in the pattern of change over time seen for many of the symptoms presented in Table 4. For example, the RLW–30 group showed a lower baseline intensity for "hunger" than did the MRE group. This was reversed during the four test weeks, where the RLW–30 group consistently showed more intense hunger.

As can be seen in Tables 3 and 4, the significantly higher symptom intensity seen for the RLW-30 group during the various test weeks was due exclusively to significant increases from baseline values for the RLW-30 group and did not depend on any significant decreases for the MRE group. The importance of these changes can be seen from the per cent change values shown. Increases as great as 1383% ("diarrhea", Table 4) are seen even though a number of substantial changes (notably "increased urination", Table 4) could not be calculated because mean baseline levels were 0.00. These changes are among the greatest seen for any variable reported in this section.

The manner in which symptom intensity increased for the RLW-30 group is summarized in Table 5. "Hunger", "increased urination", and symptoms related to dizziness ("dizziness", "faintness", and "lightheadedness") were significantly elevated by the first test week and remained above baseline levels throughout the test. Visual disturbances ("dim vision" and/or "blurred vision") also were significantly elevated in the first test week but decreased to levels not significantly different from baseline by the fourth test week. The increases in the other types of symptoms were more transitory and were seen at significantly elevated levels only during one of the four test weeks. Thus, significant elevations occurred for "sweatiness" during the first test week, "eye irritation" during the second test week, attributes of mental and physical performance impairments ("forgetfulness" and "poor concentration", "weakness" and "poor coordination") as well as "diarrhea" in the third test week, and "feverishness" in the last test week.

Mood states (POMS). Total mood score also showed a significant overall change over time ($p<0.05$). However, as can be seen from the center panel of Figure 2, changes for both groups were smaller than those seen for symptoms.

Moreover, neither a significant overall group difference or any significant difference during any of the test weeks -- as was seen during the third test week for total symptom score -- was seen in the total mood score. Finally, the pattern of change for both groups was different from that seen for symptoms. Figure 2 shows that values are nearly identical for both groups during the pre-test week. During the first test week, it can be seen that the MRE, rather than the RLW-30, reported the greatest decrease. However, following the second test week, MRE values show an almost linear recovery to baseline values. RLW-30 values, after showing less of an initial change, continue a general decrease to the final test week.

While this difference in the overall pattern of change was not significantly different for total score, the five individual mood states presented in Table 6 confirm that such a pattern of change was significantly different for the two groups. Comparisons of the two groups for specific test weeks showed that decreases in the intensity of positive moods and increases in negative mood intensity occurred earlier for the MRE group than it did for the RLW-30 group. In the first test week, there was a significant group difference in "miserable". This was due to a significant (342%) increase over baseline intensity for the MRE group; a comparable increase (229%, nonsignificant) did not occur for the RLW-30 group until the third test week. In the second week, the MRE group showed a significant decrease in "active", which also decreased significantly for the RLW-30 group but not until the fourth test week. The only other significant group difference occurred in the third test week, this time for the item "friendly". Again, this was due to a significant decrease in the MRE group, with the RLW-30 group showing a significant decrease the following week. The third week also brought a significant increase in "fatigued" and a decrease in "clearheaded" for the RLW-30 group, the latter persisting at a level significantly below baseline into the final test week.

In general, there were more similarities than differences in mood change for the two groups. Twenty-three mood states showing significant changes over time for all subjects are presented in Appendix 7.

Performance difficulty. Total score for performance difficulty appeared to be a hybrid of effects previously seen for symptoms and mood states. There was a significant overall change ($p<0.05$) across the four test weeks. The bottom panel of Figure 2 shows that this was primarily due to an increase in the total score for the RLW-30 group. By the third test week, this score was significantly higher (122%) than that reported in the first test week; no significant change occurred for the MRE group. However, neither a significant overall group difference nor a significant group difference during specific weeks was seen. A comparison of the pattern of change in total score for the two groups, presented in Figure 3, suggests why no group differences were seen despite a significant increase over baseline for the RLW-30 group. Both the pre-test values and those for the first test week show that members of the RLW-30 group initially perceived themselves to be experiencing less performance difficulty. While the differences between the groups at both these points were not significant, they had the effect of shifting the RLW-30 curve downward so the significant increase for the RLW-30 group by the third test week did not result in a significant group difference.

The lower (nonsignificant) initial total score for the RLW-30 group was substantiated by significant pre-test differences in six individual items. Two items related to unit morale (see below) and another three related to the handling of performance problems ("notice performance problems", "identify critical performance problems", and "help improve the performance of others") showed that the RLW-30 experienced less difficulty even before the start of the test. Only one item

("coordinate body while moving") showed pre-test performance difficulty was significantly greater for the RLW-30 group. The pre-test differences related to morale were not without effect. Table 7 presents the only three performance difficulty items to show significant overall group differences. All items show that the RLW-30 group had less difficulty maintaining morale. However, two of the three items show significantly lower pre-test difficulty ratings. The pre-test rating for the third item ("improve the morale of others"), while not significantly different, shows that the RLW-30 group experienced only half the difficulty reported by the MRE group well before the test started. While the RLW-30 group progressively showed increases in the difficulty ratings of the three items -- the third week rating for "improve the morale of others", for example, was 633% above first week levels -- the ratings were still lower than those seen for the MRE group. Thus, the higher morale of the RLW-30 group appears to be related more to the nature of the group itself than the ration. Moreover, the higher morale may have attenuated mood effects (see above) and other pre-test differences may have had a comparable effect on performance ratings.

Nevertheless, there was evidence of performance impairment for the RLW-30 group. Table 8 presents eight items that showed significant overall differences between the groups in the pattern of change over time. The nature of this difference can be seen from the per cent change values shown for all but the first item listed. Compared to the first test week, difficulty ratings increased for the RLW-30 group, consistently peaking in the third test week. In contrast, the MRE group -- though starting out at higher levels -- reported progressively less difficulty over the course of the test. This resulted in a significant group difference for one item related to psychomotor abilities ("type/use telegraph") by the third test week,

with the RLW–30 group experiencing significantly more difficulty than the MRE group. Another psychomotor item ("track an object") showed a significant decrease in difficulty rating for the MRE group by the last test week. At that point, the RLW–30 group reported more difficulty than the MRE group but this difference was not significant. For the remaining items, the significant differences in overall pattern of change did not show in any significant differences at specific points in time. Only the item related to physical fitness ("lift a heavy object") showed the opposite pattern. In the first test week, the RLW–30 group reported significantly greater difficulty than did the MRE group. Subsequently, difficulty decreased significantly to the point where ratings were below those seen for the MRE group.

In addition to these effects, seventeen items (see Appendix 8) showed significant changes over time for both groups that indicated a general perception of performance deterioration as the test progressed.

Objective performance measures

Reaction time. Both simple and four–choice reaction time showed significant overall ($p<0.05$) changes over time. Comparisons of individual weeks indicated that these effects were attributable primarily to performance decrement (increased latency) in the RLW–30 group on the simple reaction time test and improved performance (decreased latency) on the four–choice reaction time test in the MRE group. This was not apparent when comparisons were made with pre–test values. However, it is questionable whether the pre–test sessions –– conducted under laboratory conditions –– served as an adequate baseline for subsequent testing conducted in the field in an unheated tent. When comparisons were made with the first test week, significant changes were seen throughout the test.

The top panel of Table 9 shows the mean latency for simple reaction time. The only value to show significant change from the pre-test baseline shows a decrease in latency (performance improvement) for the the RLW-30 group in the first test week. When such comparisons were made using the first test week as baseline, significant increases in latency (performance decrements) seen for the RLW-30 group in the second ($p<0.05$), third ($p<0.05$), and fourth ($p<0.01$) test weeks. No significant changes occurred for the MRE group. These changes are shown in Figure 4. Four-choice reaction time mean latencies are presented in the bottom panel of Table 9 and Figure 5. While there are no significant changes relative to the pre-test baseline, the MRE group showed significant decreases ($p<0.05$) relative to a first-week baseline in the third and fourth test weeks while the RLW-30 showed no significant change. Per cent change values based on a first-week baseline (Table 9, parentheses) for the performance decrement seen for the RLW-30 group on simple reaction time and the performance improvement seen on four-choice reaction time for the MRE group are small. However, the +9% increase seen for the RLW-30 group on simple reaction time in the last test week approaches the 10-20% range typical for performance tests of this type.

Self-initiated behavior. There was a significant overall ($p<0.05$) difference between the two groups in total cognitive output, with the RLW-30 group consistently completing fewer arithmetic and map-compass problems. There were also significant overall differences ($p<0.0000$) in both total output and the number of work periods initiated over the course of the four test weeks. Accuracy was the only measure that showed no significant effects.

Both initiation and output were affected in much the same manner, the difference being primarily one of degree. Table 10 shows there were increases in

both types of measures from the first to the second test weeks, followed by a decrease over the last two weeks. Compared to the first test week, only the number of work periods initiated fell significantly below first-week level. However, both measures of output (total arithmetic and total map-compass problems completed) were significantly different from those seen during the second test week. Similarly, while only initiation showed a significant overall group difference, the RLW-30 group showed lower values for both initiation and output, though the difference for the latter measures was not significant. As can be seen in Figures 6 and 7, the two groups follow a parallel course on both types of measures.

In contrast, accuracy showed no significant overall group differences. In addition, there did not appear to be any marked change over time for either group. This requires some qualification, however. Because an increasing number of subjects failed to initiate any work periods, accuracy data could not be adequately analyzed by two-way repeated-measures analysis of variance. The separate one-way analyses that were used for each week give no information about changes over time. Moreover, the mean values are based on different subjects each week. Those soldiers still working on the problems may have been unusual not only in their persistence but in the continued high levels of accuracy they demonstrated.

Discussion

The results presented in this section do not provide a simple answer to the question of whether the new ration has any adverse effects. There were relatively few significant overall group differences that could be attributed to the ration alone. Rather, significant differences were seen in patterns of change over time and at specific points along that continuum. Such findings are not an indication that the

ration has no substantial effects. Rather, they indicate that the ration cannot be evaluated apart from considerations of how long it has been consumed, what stressors the soldier consuming the ration is exposed to, and the prior condition of the soldier or the unit.

The adverse effects reported here occurred most frequently during the third test week. At that time, cumulative weight loss was the greatest (some decrease actually occurred during the fourth test week). In addition, environmental conditions and performance demands were more severe than at any other point in the test. Part of the first and fourth test weeks were spent in garrison rather than in the field. Even when only field conditions are considered, the third week appeared to be the most difficult. The coldest recorded temperatures (25^{o} Fahrenheit) and surveillance operations requiring the greatest physical exertion (mountain reconnaissance) occurred during that time. To the extent that actual conditions resemble those of the third test week, soldiers existing entirely on the RLW-30 can be expected to fare worse than those who have adequate food supplies. However, it is likely that even the effects seen during the third test week underrepresent potential problems. The mental performance demands and emotional stress soldiers engaged in covert operations can expect to experience could not be approximated. Other factors such as restricted water intake, known to exacerbate the effects of undernutrition (12), were excluded. In addition, the higher morale of the RLW-30 group may have attenuated a number of effects.

Within this context, the self-reported symptoms provide the greatest cause for concern. The total symptom score was significantly elevated above baseline values only for the RLW-30 group. This was seen throughout the four test weeks and resulted in a significant difference between the two groups by the third test week.

Moreover, there were significant group differences in the intensity of individual symptoms as early as the first test week and as late as the fourth. In all cases, the RLW-30 group was more symptomatic than the MRE group. No pre-test differences were found that could explain these effects. This was true not only for items of the Environmental Symptoms Questionnaire, but related personality measures. Anxiety and external locus of control have been correlated with greater symptom reporting (13). No significant differences were seen for either of these variables. The symptom differences also could not be easily explained in terms of non-specific changes or response bias. If the results occurred because the RLW-30 group expected to feel worse, comparable differences should have been seen on measures of mood; this did not occur. Even if the soldiers expected to experience certain symptoms, this does not account for time-course differences in intensity level. Good within-subject correlations have, in fact, been shown for specific symptoms and objective measures such as blood glucose levels or systolic blood pressure (14,15). While the correspondence between objective measures and the self-reported symptom data in this test remains to be determined, discrepancies should not -- in and of themselves -- invalidate the subjective data. Most objective measures were not obtained during the third test week when symptom intensity was at peak levels. Moreover, self-report data encompassed an entire week; comparable objective data represented discrete points and usually were obtained under the least demanding conditions.

Apart from suggesting that soldiers existing entirely on the RLW-30 ration may experience health problems, the symptom data also suggest potential performance impairments. Visual disturbances, dizziness and related phenomena, shaking hands, weakness, poor coordination, forgetfulness and poor concentration all have obvious

operational implications. Performance was more specifically measured by a comprehensive questionnaire and select objective measures. The pattern seen for the total performance difficulty score followed a similar pattern to that seen for the total symptom score, though the differences between the two groups were less pronounced. Pre-test differences played a more prominent role here than for symptoms. Overall, the RLW-30 group initially reported a level of performance difficulty that was 17% lower than that reported by the MRE group. While this did not represent a significant difference, six individual items showed significant pre-test differences and five of these indicated that the RLW-30 group experienced less performance difficulty even before the start of the test. Nevertheless, specific aspects of both the self-report and objective performance data suggested that performance problems may be associated with the RLW-30 ration.

Three different types of performance problems may have been involved. First, a specific ability or class of abilities may have been degraded. From the self-report data, the earliest indication of this was seen in a physical ability ("lift a heavy object"). The RLW-30 group reported significantly more difficulty than the MRE during the first test week, but this diminished over time. The extent to which this represents an actual rather than perceived difficulty cannot be ascertained. While objective tests of physical fitness were administered, none involved lifting and all but one were only administered pre- and post-test. Grip strength was measured throughout and showed no significant effects. However, it should be noted that the effects of inadequate caloric intake on grip strength appear to depend on when it is measured. In this test, measurements were obtained in the morning; in a previous study (12), decrements were seen in evening but not morning hours. Other self-report items suggest that degradation may have occurred for psychomotor

("type/use telegraph") abilities. There is some corroboration for this. When soldiers were observed using the computers to respond to questionnaires and take reaction time tests, it was apparent that some individuals in the RLW-30 group were having increasing difficulties. As an extreme case, one RLW-30 group member was able to use the computer only by supporting one hand with the other during the last test week. Significant decrements have been shown in general tapping ability during chronic caloric deprivation (10). Moreover, significant decrements were seen for the RLW-30 group in the simple reaction time test when first test week performance was compared to that of subsequent weeks.

In addition to decrements in specific abilities, two other types of problems transcending discrete impairments may have been associated with the RLW-30 ration. For one, learning or adaptation may have been affected. Self-rated performance difficulty for seven of the eight items that showed significant differences in the pattern of change (though not necessarily significant group differences at any point) all followed a similar course. Psychomotor ("type/use telegraph" and "track an object"), cognitive ("remember bits of unrelated information" and "orient self/object"), general performance attributes ("complete all parts of a problem"), and integrity ("observe regulations on equipment/personnel use") abilities all were reported to become progressively less difficult for the MRE group; this was not seen for the RLW-30 group. A similar pattern was seen for four-choice reaction time, where response latency decreased relative to the first test week for the MRE but not the RLW-30 group. The other more general problem may have involved performance motivation. With reference to cognitive abilities, Mohs (16) has observed that nutritional deficits have greater effects on what individuals are willing to do than on what they can do. This, essentially, is similar to the rationale provided by Levitsky

and Strupp (9) for the measures of self-initiation used in this test. The data from these measures tend to confirm such a view. Overall, the RLW-30 group performed significantly less voluntary cognitive work than did the MRE group while performing at a comparable level of accuracy. Pre-test data were not available to ascertain that this did not represent a general difference between the two teams, and the impact of greater visual difficulties reported by the RLW-30 group cannot be ruled out. However, the view that undernutrition affects performance apart from ability to perform has been proposed in a broad range of contexts and deserves consideration. It has been hypothesized with respect to physical abilities, for example, that discretionary activities selectively decrease when caloric intake is reduced (17,18).

From the findings presented in this section, therefore, there is reason to expect that Special Operations soldiers subsisting exclusively on the RLW-30 ration may experience some health and performance problems. There is no evidence that such problems could seriously compromise their mission; this, however, would depend to a great degree on external conditions and the nature of the soldiers involved. There is also no evidence that these problems would be any greater than those that might result from an inability or unwillingness to carry adequate amounts of a bulkier or heavier ration such as the MRE. Had this test been designed to permit the soldiers themselves to determine how much of each type of ration they would pack for a month, the advantages rather than the shortcomings of the new ration might have been more apparent. However, it does appear that a ration that is both compact and light-weight and calorically-adequate is necessary for operations that are conducted for extended periods without resupply.

Conclusions

1. Soldiers consuming the RLW–30 ration generally perceived themselves to be more symptomatic than those consuming calorically–adequate amounts of the MRE ration. In total, self–reported symptom intensity was the greatest for the RLW–30 group when environmental and physical demands were the greatest. Individual symptoms showing primary effects included hunger, increased urination, dizziness and related phenomena (dizziness, faintness, lightheadedness), visual disturbances (dim vision, blurred vision), sweatiness, eye irritation, cognitive disturbances (forgetfulness, poor concentration), and motor disturbances (weakness, poor coordination). Increased intensity of some symptoms was evident as early as the first test week and as late as the last week.

2. Soldiers consuming the RLW–30 ration also perceived themselves to have greater performance difficulties than did the MRE group and showed some decrements on objective performance tests than were not seen for the MRE group. When objective and subjective data were considered together, three types of problems were apparent. First, decrements in specific physical (lifting) and psychomotor abilities (simple reaction time, typing/using telegraph) were seen. Second, a general pattern of decreased adaptability to field conditions was seen across a range of abilities that included psychomotor, cognitive, and organizational abilities. Third, the level of self–initiation in cognitive performance was lower (though no baseline data were available for comparison).

3. In contrast to symptom and performance findings, there was little evidence that the RLW–30 ration had an adverse effect on mood. However, mood effects may have been attenuated by the higher morale that the RLW–30 group reported even before the start of the test.

REFERENCES

1. Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. An inventory for measuring depression. Archives of General Psychiatry, 4: 53–63, 1961.

2. Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. STAI manual for the State–Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press, Inc., 1970.

3. Rotter, J. B. Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 80 (Whole No. 609), 1966.

4. Munro, I., & Rauch, T. M. The use of subjective measures for basic problem–definition. Proceedings of the 28th Annual Conference of the Military Testing Association, in press.

5. Kobrick, J. L., & Sampson, J. B. New inventory for the assessment of symptom occurrence and severity at high altitude. Aviation, Space and Environmental Medicine, 50: 925–929, 1979.

6. NcNair, D. M., Lorr, M., & Droppleman, L. F. EITS manual for the Profile of Mood States (POMS). San Diego: Educational and Industrial Testing Service, 1981.

7. Lieberman, H. R., Corkin, S., Spring, B. J., Wurtman, R. J., & Growdon, J. The effects of neurotransmitter precursors on human behavior. American Journal of Clinical Nutrition, 42: 366–370, 1985.

8. Lieberman, H. R., Spring, B. J., & Garfield, G. S. The behavioral effects of food constituents: Strategies used in studies of amino acids, proteins, carbohydrates, and caffeine. Nutrition Reviews, 44(Suppl.): 61–70, 1986.

9. Levitsky, D. A., & Strupp, B. J. Nutritional deficiencies and cognition. Proceedings, Cognitive Testing Methodology (pp 81–100). Washington, D.C.: National Academy Press, 1986.

10. Keys, A., Brozek, J., Henschel, A., Mickelsen, O., & Taylor, H. L. The biology of human starvation. Minneapolis: The University of Minnesota Press, 1950.

11. Banderet, L. E., Lieberman, H. R., Francesconi, R. P., Shukitt, B. L., Goldman, R. F., Schnakenberg, D. D., Rauch, T. M., Rock, P. B., & Meadors, G. F. Development of a paradigm to assess nutritive and biochemical substances: A preliminary report of the effects of tyrosine on altitude– and cold–induced stress responses. Proceedings, Biochemical Enhancement of Performance. NATO Advisory Group for Aerospace Research and Development, in press.

12. Grande, F. Impact of food restriction on physical performance. Proceedings, Predicting decrements in military performance due to inadequate nutrition (pp 81–97). Washington, D. C.: National Academy Press, 1986.

13. Pennebaker, J. W. The psychology of physical symptoms (pp 136–138). New York: Springer–Verlag New York, Inc., 1982.

14. Pennebaker, J. W., Cox, D. J., Gonder–Frederick, L. A., Wunsch, M., Evans, W. S., & Pohl, S. Physical symptoms related to blood glucose in insulin dependent diabetics. Psychosomatic Medicine, 43: 489–500 1981.

15. Pennebaker, J. W., Gonder–Frederick, L. A., Stewart, H., Elfman, L. & Skelton, J. A. Physical symptoms associated with blood pressure. Psychophysiology, 19: 201–210, 1982.

16. Mohs, R. Cognitive testing methods for assessing military performance. Proceedings, Predicting decrements in military performance due to inadequate nutrition. Washington, D. C.: National Academy Press, 1986.

17. Calloway, D. H. Functional consequences of malnutrition. Review of Infectious Diseases, 4: 736–745, 1982.

18 Gorsky, R. D., & Calloway, D. H. Activity pattern changes with decrease in food energy intake. Human Biology, 55: 577–586, 1983.

Table 1. PRE-TEST DIFFERENCES IN PERSONALITY TRAITS[1]

	MEAN SCORE ± SEM		ANOVA	
	MRE	RLW-30	F	p
depression	3.06 ±1.03	3.89 ±1.12	0.29	NS
anxiety	29.65 ±1.35	31.00 ±1.95	0.32	NS
locus of control	6.82 ±0.58	9.06 ±1.27	2.99	NS

[1] One-way analysis of variance. MRE N=17 (one subject declined tests)

Table 2. TOTAL SCORES FOR SELF-REPORTED SYMPTOMS, MOOD STATES[1], AND PERFORMANCE DIFFICULTY[2,3].

	MEAN SCORE ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
				SYMPTOMS					
MRE	20.28	29.67	29.78	28.94**	30.83	+46	+47	+43	+52
	±3.15	±5.00	±3.80	±4.19	±5.69				
RLW-30	20.22	37.61*	38.06*	49.83**	41.28**	+86	+88	+146	+104
	±4.01	±5.74	±6.12	±10.54	±8.34				
				MOOD STATES					
MRE	63.70	56.29	49.76	54.82	61.94	−12	−22	−14	−3
	±4.05	±3.82	±3.66	±4.13	±8.06				
RLW-30	63.50	62.17	55.94	59.17	53.28	−2	−12	−7	−16
	±3.33	±3.73	±3.84	±6.03	±5.77				
				PERFORMANCE DIFFICULTY					
MRE	40.67	42.89	42.11	50.78	45.61	–	−2	+18	+6
	±7.31	±10.01	±11.58	±12.38	±9.84				
RLW-30	33.72	27.94	36.33	61.89*	47.56	–	+30	+122	+70
	±8.02	±6.57	±8.78	±19.1	±11.05				

[1] MRE N=17 (one subject declined POMS)

[2] Performance difficulty pre-test data submitted to separate one-way analysis of variance because of different garrison and FTX performance demands. Post hoc comparisons, per cent change values based on first test week data.

[3] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$. ** = $p<0.01$).

Table 3. INDIVIDUAL SYMPTOMS SHOWING SIGNIFICANT OVERALL (ANOVA) GROUP DIFFERENCES.[1]

	MEAN INTENSITY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
dim vision									
MRE	0.00 ±0.00	0.06 ±0.06	0.00* ±0.00	0.00* ±0.00	0.06** ±0.06	–	–	–	–
RLW-30	0.11 ±0.08	0.67* ±0.28	0.61* ±0.18	0.78** ±0.27	0.33 ±0.14	+509	+455	+609	+200
blurred vision									
MRE	0.06 ±0.06	0.00 ±0.00	0.00** ±0.00	0.00** ±0.00	0.06 ±0.06	−100	−100	−100	0
RLW-30	0.22 ±0.10	0.44 ±0.17	0.78* ±0.27	0.67 ±0.34	0.50 ±0.26	+100	+255	+205	+127
dizziness									
MRE	0.06 ±0.06	0.28 ±0.23	0.06 ±0.06	0.00* ±0.00	0.28 ±0.18	+367	0	−100	+367
RLW-30	0.11 ±0.08	1.00* ±0.30	0.67 ±0.27	1.17** ±0.35	1.00* ±0.37	+809	+509	+964	+809
faintness									
MRE	0.00 ±0.00	0.06 ±0.06	0.00 ±0.00	0.00** ±0.00	0.17 ±0.09	–	–	–	–
RLW-30	0.00 ±0.00	0.56 ±0.27	0.33 ±0.16	0.78** ±0.26	0.61 ±0.28	–	–	–	–
hand tremor									
MRE	0.06 ±0.06	0.06 ±0.06	0.11 ±0.08	0.06 ±0.06	0.11 ±0.08	0	+83	0	+83
RLW-30	0.11 ±0.08	0.17 ±0.09	0.33 ±0.14	0.33 ±0.14	0.28 ±0.14	+55	+200	+200	+155
warmth									
MRE	0.11 ±0.08	0.72 ±0.23	0.44 ±0.18	0.72 ±0.23	0.44 ±0.18	+555	+300	+555	+300
RLW-30	0.94 ±0.33	1.44 ±0.35	1.06 ±0.26	1.00 ±0.23	0.67 ±0.21	+53	+13	+6	−29

[1] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$.

Table 4. INDIVIDUAL SYMPTOMS SHOWING A SIGNIFICANT ANOVA GROUP-TIME INTERACTION.[1]

	MEAN INTENSITY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
hunger									
MRE	1.94 ±0.44	1.22** ±0.26	1.17** ±0.29	1.17** ±0.28	1.6** ±0.39	−37	−40	−40	−14
RLW-30	1.28 ±0.39	3.50** ±0.39	3.17** ±0.51	2.78** ±0.58	3.11** ±0.54	+173	+148	+117	+143
increased urination									
MRE	0.06 ±0.06	0.11** ±0.08	0.28** ±0.14	0.17** ±0.17	0.11** ±0.08	+83	+367	+183	+83
RLW-30	0.00 ±0.00	1.94** ±0.47	1.50** ±0.40	1.89** ±0.54	1.94** ±0.52	–	–	–	–
sweatiness									
MRE	0.00 ±0.00	0.11** ±0.11	1.17 ±0.17	0.11 ±0.11	0.11 ±0.11	–	–	–	–
RLW-30	0.11 ±0.11	0.67** ±0.28	0.00 ±0.00	0.17 ±0.12	0.22 ±0.15	+509	−100	+54	+100
lightheadedness									
MRE	0.39 ±0.28	0.50 ±0.25	0.11* ±0.11	0.17** ±0.09	0.39 ±0.20	+28	−72	−56	0
RLW-30	0.17 ±0.09	1.06* ±0.30	1.00* ±0.27	1.33** ±0.33	1.11* ±0.30	+524	+488	+682	+553
eye irritation									
MRE	0.17 ±0.09	0.44 ±0.23	0.17** ±0.09	0.17 ±0.09	0.11 ±0.08	+159	0	0	−35
RLW-30	0.39 ±0.18	0.22 ±0.13	0.89** ±0.28	0.50 ±0.23	0.17 ±0.09	−44	+128	+28	−56
diarrhea									
MRE	0.17 ±0.12	0.06 ±0.06	0.00 ±0.00	0.06** ±0.06	0.00 ±0.00	−65	−100	−65	−100
RLW-30	0.06 ±0.06	0.39 ±0.24	0.50 ±0.28	0.89** ±0.40	0.61 ±0.35	+550	+733	+1383	+917

(cont'd)

Table 4 (cont'd)

	MEAN INTENSITY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
forgetfulness									
MRE	0.33 ±0.14	0.22 ±0.13	0.06 ±0.06	0.17** ±0.09	0.39 ±0.16	−33	−82	−49	+18
RLW−30	0.11 ±0.11	0.28 ±0.14	0.33 ±0.20	0.89** ±0.34	0.44 ±0.18	+155	+200	+709	+300
poor concentration									
MRE	0.39 ±0.18	0.56 ±0.18	0.28 ±0.11	0.33** ±0.14	0.50 ±0.19	+44	−28	−15	+28
RLW−30	0.28 ±0.14	0.50 ±0.17	0.61 ±0.28	1.22** ±0.40	0.72 ±0.29	+79	+118	+336	+157
weakness									
MRE	0.44 ±0.17	0.44 ±0.17	0.50 ±0.19	0.50** ±0.20	0.78 ±0.27	0	+14	+14	+77
RLW−30	0.33 ±0.14	1.22 ±0.30	1.22 ±0.26	1.67** ±0.44	1.22 ±0.34	+270	+270	+406	+270
poor coordination									
MRE	0.11 ±0.08	0.39 ±0.20	0.17 ±0.09	0.22** ±0.10	0.39 ±0.16	+255	+55	+100	+255
RLW−30	0.11 ±0.08	0.22 ±0.13	0.55 ±0.20	0.94** ±0.29	0.56 ±0.17	+100	+400	+755	+409
feverishness									
MRE	0.00 ±0.00	0.11 ±0.05	0.00 ±0.08	0.00 ±0.08	0.00* ±0.08	–	–	–	–
RLW−30	0.11 ±0.03	0.00 ±0.16	0.00 ±0.09	0.06 ±0.05	0.50* ±0.12	−100	−100	−45	+355

[1] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$).

Table 5. SIGNIFICANT INCREASES IN SYMPTOM INTENSITY FOR THE RLW-30 GROUP

	TEST WEEK			
	1	2	3	4
hunger	+	+	+	+
increased urination	+	+	+	+
dizziness, faintness, lightheadedness	+	+	+	+
dim vision, blurred vision	+	+	+	
sweatiness	+			
eye irritation		+		
forgetfulness, poor concentration			+	
weakness, poor coordination			+	
diarrhea			+	
feverishness				+

Table 6. INDIVIDUAL MOOD STATES SHOWING A SIGNIFICANT ANOVA GROUP–TIME INTERACTION.[1,2]

	MEAN INTENSITY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
NEGATIVE MOODS									
miserable									
MRE	0.24 ±0.06	1.06** ±0.26	0.47 ±0.11	0.29 ±0.07	0.76 ±0.19	+342	+96	+21	+217
RLW–30	0.17 ±0.04	0.28 ±0.07	0.44 ±0.10	0.56 ±0.13	0.39 ±0.09	+65	+159	+229	+129
fatigued									
MRE	0.94 ±0.25	0.94 ±0.16	0.65 ±0.17	0.88 ±0.24	1.18 ±0.24	0	−31	−6	+25
RLW–30	0.44 ±0.18	1.22 ±0.26	1.06 ±0.25	1.33* ±0.27	0.94 ±0.25	+177	+141	+202	+114
POSITIVE MOODS									
active									
MRE	3.00 ±0.73	2.35 ±0.57	1.76** ±0.43	2.65 ±0.64	2.41 ±0.58	−22	−41	−12	−20
RLW–30	3.00 ±0.71	2.39 ±0.56	2.28 ±0.54	2.22 ±0.53	1.67** ±0.39	−20	−24	−26	−44
friendly									
MRE	2.59 ±0.12	2.29 ±0.22	2.06 ±0.16	1.76* ±0.24	1.88* ±0.27	−12	−21	−32	−27
RLW–30	2.89 ±0.20	2.67 ±0.23	2.56 ±0.18	2.61 ±0.26	1.94** ±0.30	−8	−11	−10	−33
clearheaded									
MRE	3.18 ±0.23	2.29 ±0.31	2.41 ±0.30	2.71 ±0.28	2.65 ±0.26	−28	−2	−15	−17
RLW–30	3.28 ±0.28	3.00 ±0.28	2.94 ±0.26	2.11* ±0.28	2.17* ±0.35	−9	−10	−36	−34

[1] MRE N=17 (one subject declined test)

[2] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; *=$p<0.05$, **=$p<0.01$.

Table 7. INDIVIDUAL PERFORMANCE RATINGS[1] SHOWING SIGNIFICANT OVERALL (ANOVA) GROUP DIFFERENCES.[2]

	MEAN DIFFICULTY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
work under duress without complaining									
MRE	*0.67 ±0.20	0.78 ±0.21	1.00 ±0.33	0.94 ±0.26	0.83 ±0.31	–	+28	+20	+6
RLW-30	0.22 ±0.10	0.11 ±0.08	0.50 ±0.19	0.44 ±0.23	0.50 ±0.17	–	+355	+300	+355
avoid making fun of others									
MRE	*0.89 ±0.23	0.72 ±0.18	0.78 ±0.17	1.17 ±0.29	1.00 ±0.27	–	+8	+63	+39
RLW-30	0.33 ±0.16	0.39 ±0.18	0.44 ±0.23	0.50 ±0.25	0.28 ±0.14	–	+13	+28	-28
improve the morale of others									
MRE	0.67 ±0.21	0.61 ±0.16	0.78 ±0.29	0.89 ±0.28	1.00 ±0.33	–	+28	+46	+64
RLW-30	0.33 ±0.14	0.06 ±0.06	0.17 ±0.09	0.44 ±0.23	0.44 ±0.23	–	+183	+633	+633

[1] Performance difficulty pre-test and test ratings submitted to separate ANOVA and post hoc analyses. Post hoc comparisons, per cent change based on first test week data.

[2] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$.

Table 8. INDIVIDUAL PERFORMANCE RATINGS[1] SHOWING A SIGNIFICANT ANOVA GROUP-TIME INTERACTION.[2]

	MEAN DIFFICULTY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
lift a heavy object									
MRE	0.56 ±0.17	1.11* ±0.23	0.83 ±0.27	1.17 ±0.32	1.06 ±0.33	–	−25	+5	−5
RLW-30	0.72 ±0.18	1.83 ±0.29	1.17** ±0.20	1.00** ±0.26	0.94** ±0.24	–	−36	−45	−49
type/use telegraph									
MRE	1.61 ±0.31	0.83 ±0.29	0.67 ±0.21	0.28* ±0.16	0.17 ±0.09	–	−19	−66	−80
RLW-30	0.89 ±0.29	0.67 ±0.24	0.67 ±0.21	1.06 ±0.39	0.67 ±0.26	–	0	+58	0
track an object									
MRE	0.61 ±0.18	0.83 ±0.26	0.56 ±0.20	0.44 ±0.20	0.17* ±0.09	–	−33	−47	−80
RLW-30	0.61 ±0.27	0.33 ±0.14	0.44 ±0.18	0.50 ±0.23	0.50 ±0.15	–	+33	+52	+52
orient self/object									
MRE	0.28 ±0.18	0.61 ±0.24	0.50 ±0.17	0.44 ±0.20	0.28 ±0.11	–	−18	−28	−54
RLW-30	0.11 ±0.08	0.11 ±0.11	0.28 ±0.14	0.61 ±0.23	0.39 ±0.14	–	+155	+455	+255
remember bits of unrelated information									
MRE	0.72 ±0.24	0.67 ±0.23	0.44 ±0.17	0.50 ±0.19	0.22 ±0.10	–	−34	−25	−67
RLW-30	0.67 ±0.23	0.39 ±0.14	0.61 ±0.22	0.88 ±0.28	0.67 ±0.18	–	+56	+128	+72
complete all parts of a task									
MRE	0.17 ±0.09	0.67 ±0.21	0.39 ±0.20	0.39 ±0.14	0.56 ±0.26	–	−42	−42	−16
RLW-30	0.50 ±0.24	0.11 ±0.08	0.50 ±0.23	0.78 ±0.33	0.44 ±0.12	–	+355	+609	+300
observe regulations on equipment/personnel use									
MRE	1.00 ±0.28	0.56 ±0.26	0.94 ±0.16	0.44 ±0.18	0.33 ±0.18	–	+68	−21	−41
RLW-30	0.67 ±0.28	0.22 ±0.17	0.33 ±0.20	0.83 ±0.29	0.44 ±0.12	–	+50	+277	+100

cont'd

Table 8 (cont'd)

	MEAN DIFFICULTY ± SEM					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
come up with new solutions to problems									
MRE	0.67 ±0.26	0.22 ±0.13	0.39 ±0.16	0.33 ±0.16	0.17 ±0.12	–	+77	+50	−23
RLW−30	0.22 ±0.10	0.17 ±0.09	0.17 ±0.09	0.56 ±0.23	0.67 ±0.24	–	0	+229	+294

[1] Performance difficulty pre−test and test ratings submitted to separate ANOVA and post hoc analyses. Post hoc, per cent change based on first test week data.

[2] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$.

Table 9. REACTION TIME.[1], [2]

	MEAN LATENCY (MSEC) ± SEM					% CHANGE[3]			
	PRE	1	2	3	4	1	2	3	4
				SIMPLE					
MRE	374 ±11	369 ±10	366 ±9	361 ±10	369 ±11	−1	−2 (−1)	−5 (−2)	−1 (0)
RLW−30	366 ±10	344* ±6	364 ±9	363 ±8	376 ±8	−6	−1 (+5)	−1 (+6)	−3 (+9)
				FOUR-CHOICE					
MRE	599 ±15	625 ±39	583 ±19	552 ±16	560 ±17	+4	−3 (−7)	−8 (−11)	−7 (10)
RLW−30	573 ±13	553 ±14	544 ±10	551 ±14	550 ±15	−4	−5 (−2)	−4 (0)	−4 (−1)

[1] MRE N=17, RLW−30 N=16

[2] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$.

[3] % change values in parentheses based on first test week

Table 10. SELF-INITIATED BEHAVIOR.[1,2]

		MEAN SCORE ± SEM				% CHANGE			
	PRE	1	2	3	4	1	2	3	4
INITIATION									
Total work periods									
MRE	–	4.44 ±0.65	4.50 ±0.55	1.78** ±0.40	1.06** ±0.25	–	+1	−60	−76
RLW-30	–	3.28 ±0.63	3.44 ±0.89	1.11** ±0.59	0.67** ±0.42	–	+5	−66	−80
OUTPUT									
total arithmetic problems completed									
MRE	–	545.94 ±89.26	877.44 ±196.23	335.28 ±85.53	192.06 ±83.53	–	+61	−39	−65
RLW-30	–	277.17 ±67.20	677.22 ±263.12	45.94 ±33.55	24.94 ±15.61	–	+144	−83	−91
total map-compass problems completed									
MRE	–	81.22 ±12.84	135.28 ±29.47	49.28 ±13.13	29.17 ±13.25	–	+67	−39	−64
RLW-30	–	39.00 ±11.15	89.94 ±40.32	8.22 ±6.36	4.44 ±2.67	–	+131	−79	−89
ACCURACY									
Per cent correct: arithmetic problems									
MRE	–	96.00 ±0.49	97.33 ±0.33	96.64 ±0.56	98.00 ±0.63	–	+1	+1	+2
RLW-30	–	97.17 ±0.54	98.07 ±0.36	91.50 ±6.50	98.00 ±0.58	–	+1	−6	+1
Per cent correct: map-compass problems									
MRE	–	87.00 ±1.57	88.78 ±1.42	85.55 ±5.49	81.40 ±13.18	–	+2	−2	−6
RLW-30	–	89.77 ±2.94	93.08 ±1.94	94.00 ±6.00	94.67 ±4.37	–	+4	+5	+5

Table 10 (cont'd)

[1] Post-hoc, per cent change based on first test week values. Weekly accuracy scores submitted to separate one-way ANOVA analyses.

[2] Asterisks indicate significant post hoc differences (asterisk above = group difference, asterisk beside = difference from baseline; * = $p<0.05$, ** = $p<0.01$.

FIGURE 1. SELF-REPORTED SYMPTOMS

COMBINED EFFECTS

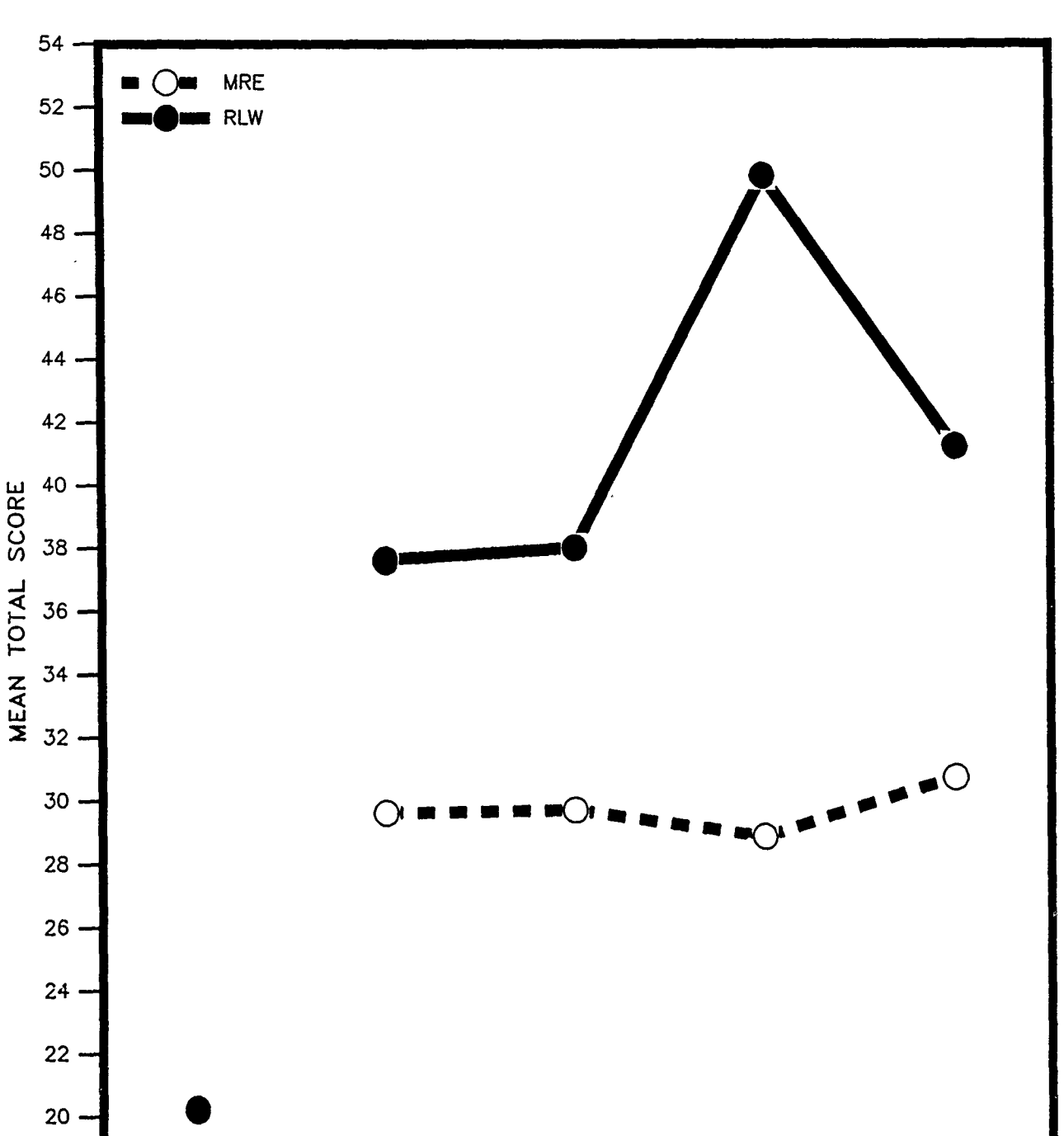


FIGURE 2. SELF-REPORTED MOOD

COMBINED EFFECTS

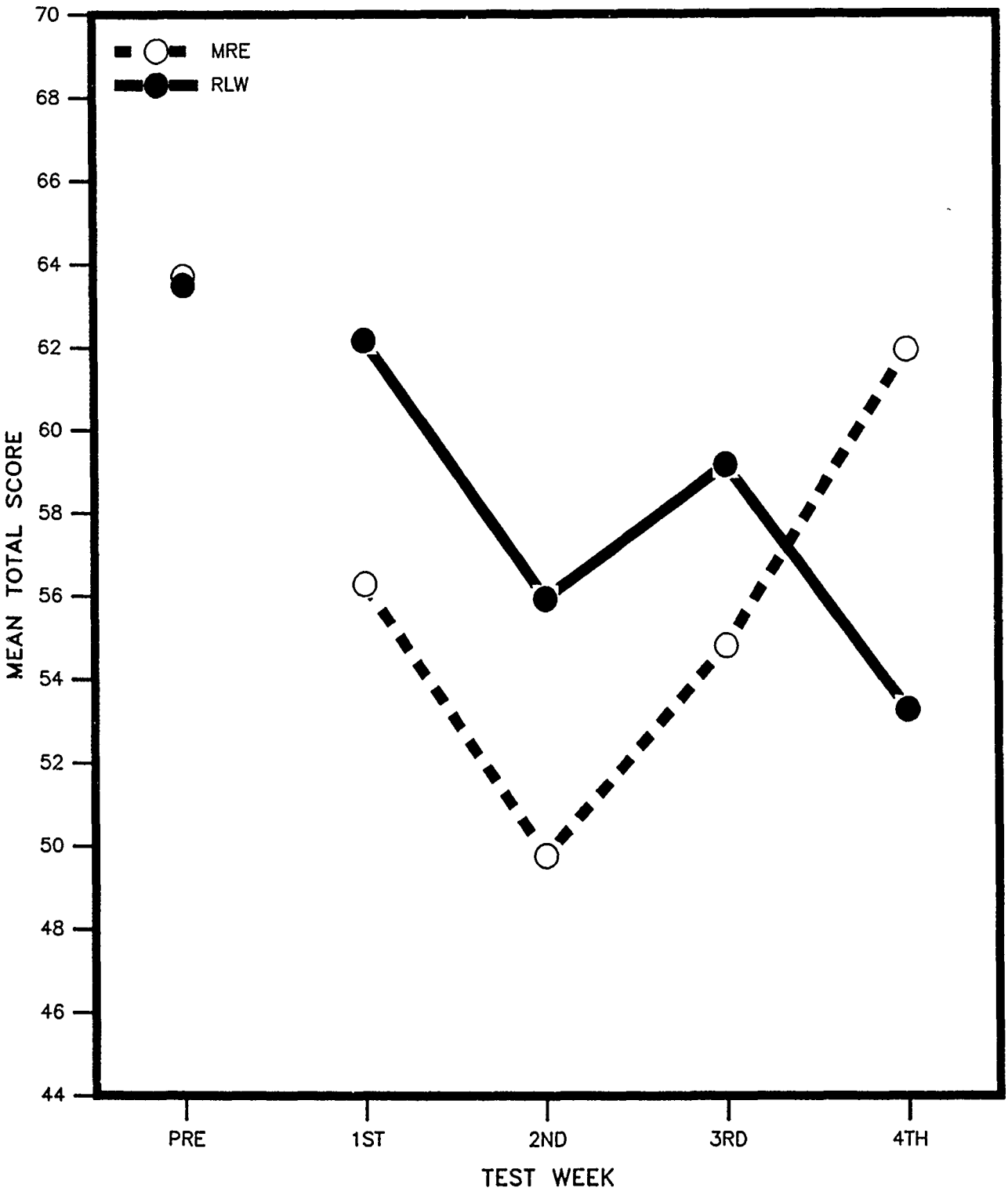


FIGURE 3. SELF-REPORTED PERFORMANCE DIFFICULTY

COMBINED EFFECTS

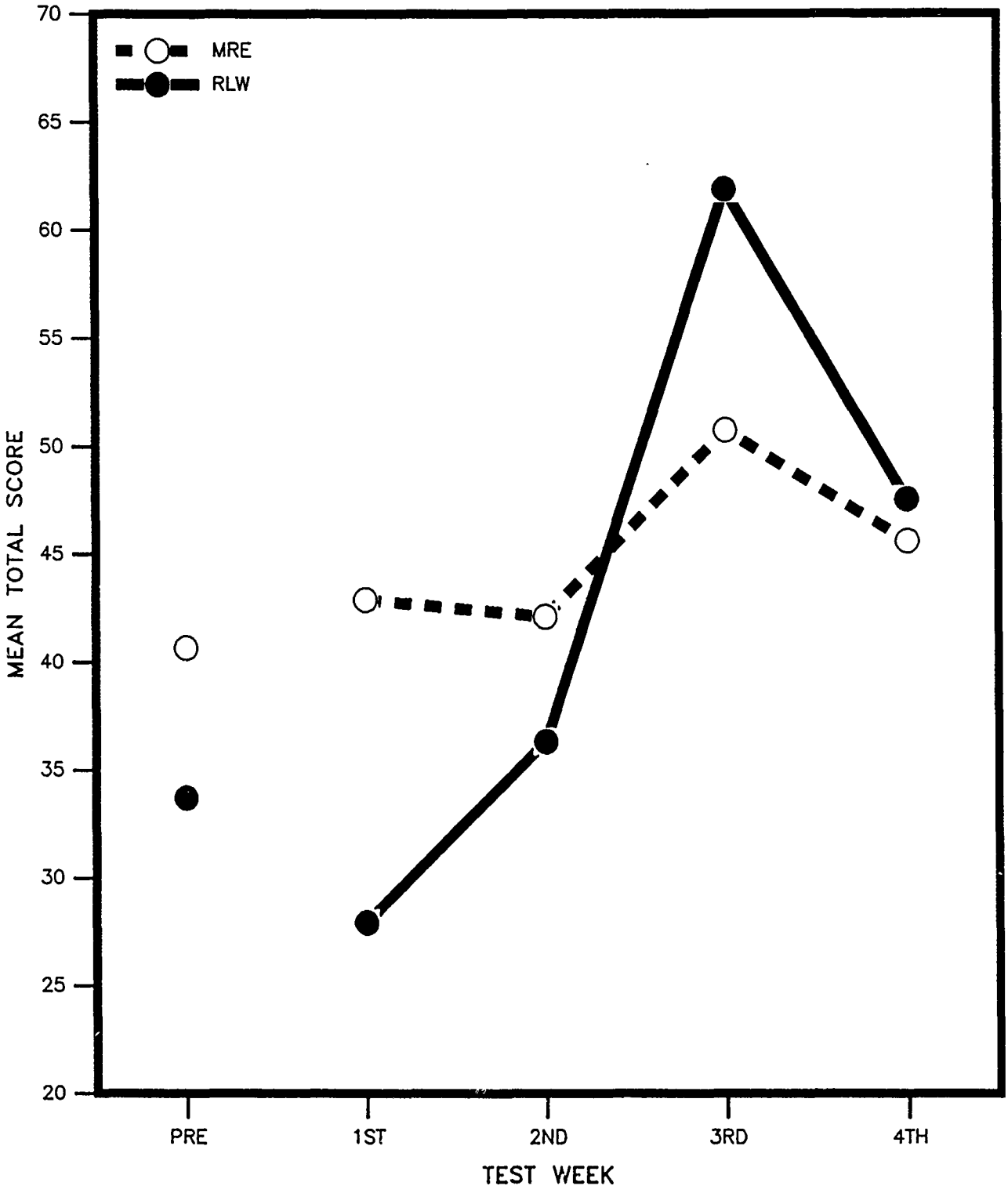


FIGURE 4. REACTION TIME

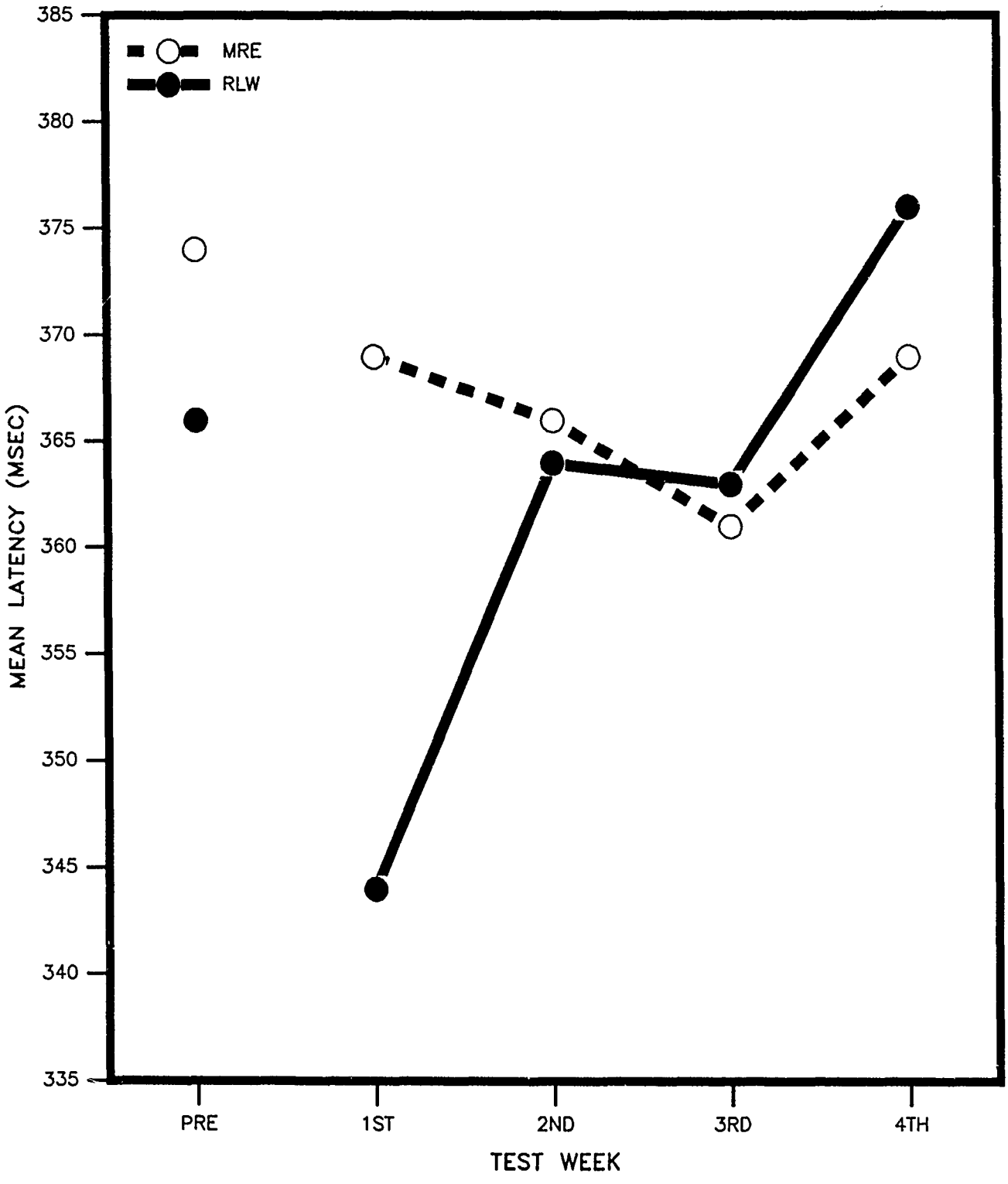


FIGURE 5. REACTION TIME

FOUR-CHOICE REACTION TIME

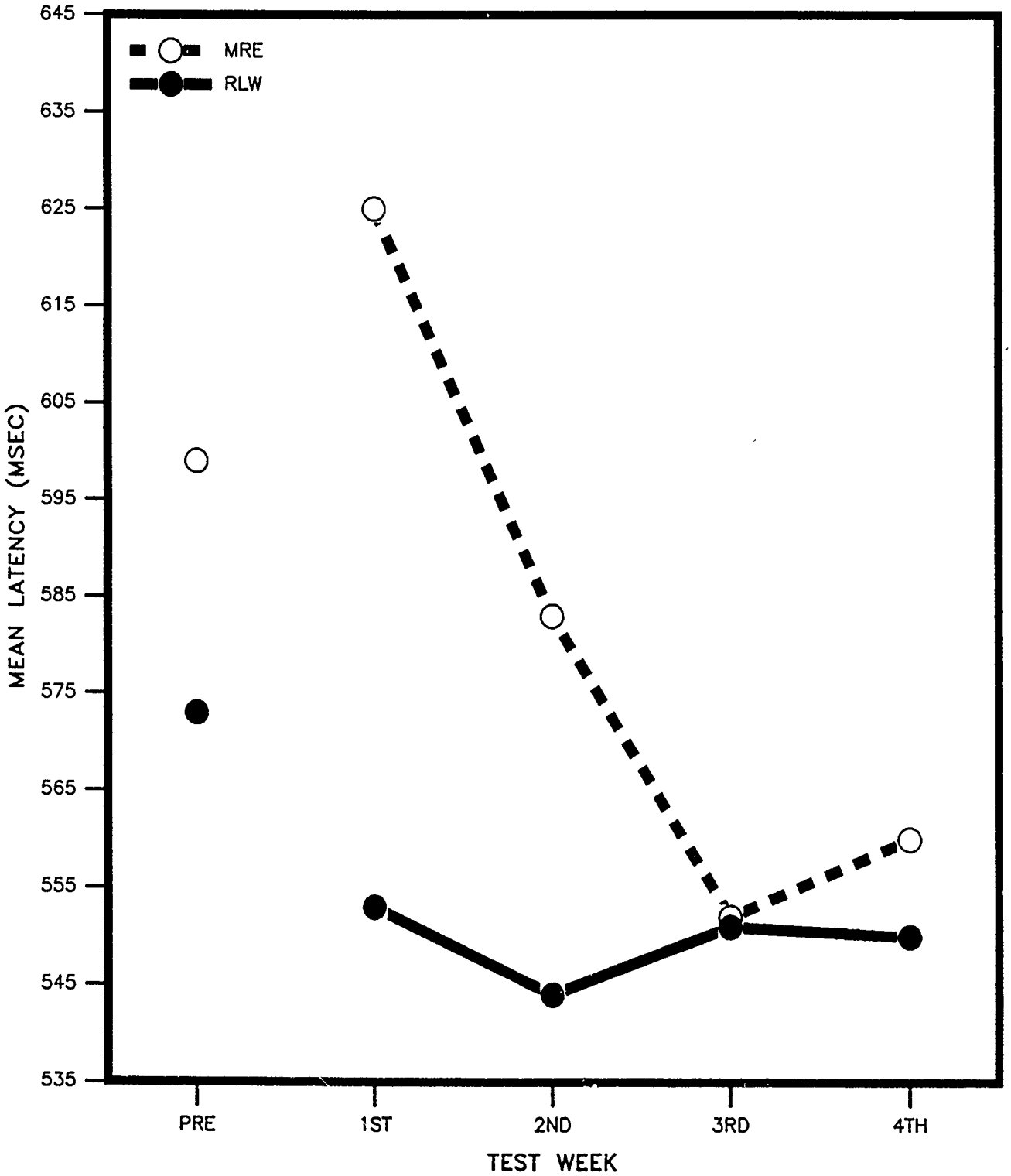


FIGURE 6. SELF-INITIATED BEHAVIOR

WORK PERIODS

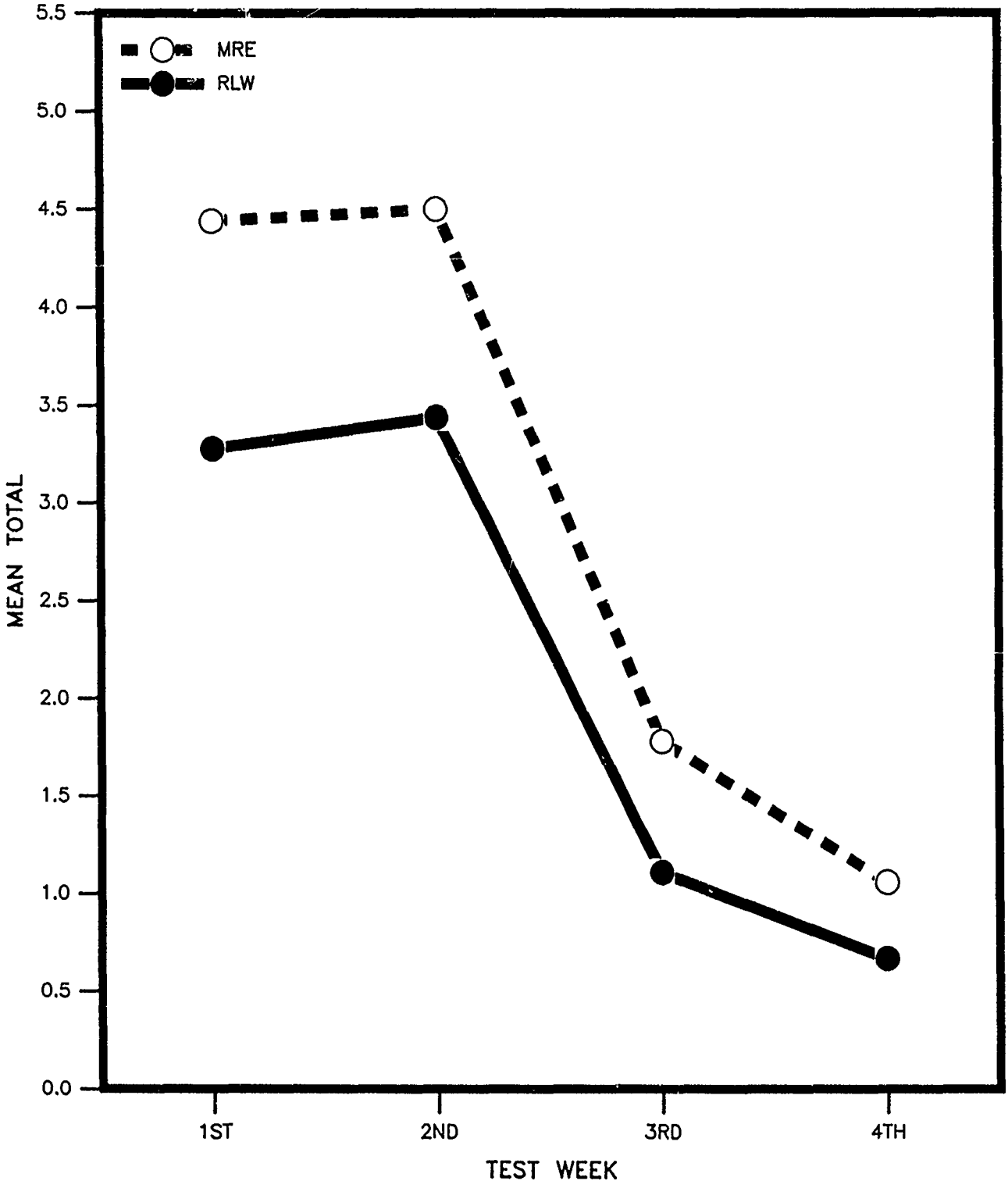
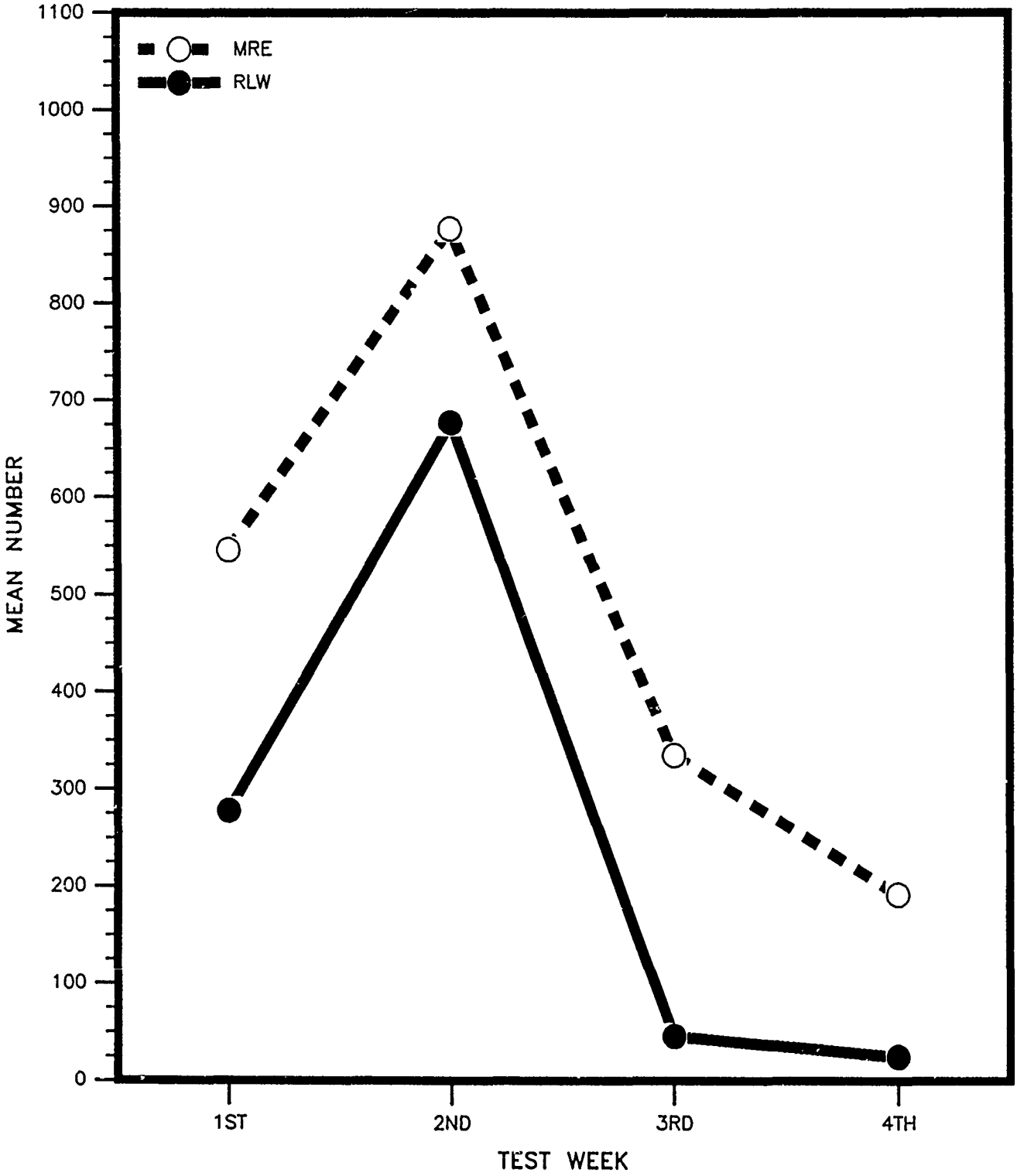


FIGURE 7. SELF-INITIATED BEHAVIOR

COMPLETED ARITHMETIC PROBLEMS



DAILY COGNITIVE COMPUTER TASKS: VIGILANCE & ENCODING

DAILY COGNITIVE COMPUTER TASKS: VIGILANCE & ENCODING

Methods

Pocket Computer. Vigilance and encoding tasks were selected because of their relevance to Special Operations Forces (SOF) missions. Vigilance was selected because of the importance of sustained attention (e.g., surveillance or guard duty). Encoding was selected because encoding and decoding messages are part of SOF's typical operations. While no literature is available on the effects of 30 day caloric restriction on this sort of performance, it has been shown that diet can affect vigilance performance in the short term (1). Both the vigilance and encoding tasks were done on Sharp PC-1500A pocket computers. The dimensions of the computers were 195mm(W) x 25.5mm(H) x 86mm (D) and they weighed 375g each, small enough to be carried in a BDU pocket. Each computer had a 26 digit liquid crystal display of 7 x 156 dots.

Vigilance. The vigilance task was to be completed once each day in the morning. Each daily session was approximately 30 minutes in length. During each session, a series of semi-random digits was presented on the screen one at a time. Each digit was presented for approximately 1000 ms followed by a blank screen for approximately 700 ms. Targets were defined as three digit sequences in which an odd digit was followed by an even digit which was followed by a different odd digit. Distractors were defined as three digit sequences in which an odd digit was followed by an even digit which was followed by the same odd digit. Approximately 30 targets and 30 distractors were presented per session. For example, 3-4-5 was a

target while 3–4–3 was a distractor. Subjects were instructed to indicate a target by pressing the space bar on the keyboard. An asterisk ("*") would then appear to indicate that the response had been recorded.

Encoding. The encoding task was to be completed once each day in the afternoon. Each daily session lasted approximately 21 minutes. A series of semi–random five letter "words" or "messages" were presented on the screen one at a time. Each "message" was preceded by the trial number. The subjects' task was to encode the message using the trigraph codes provided and shown in Figure 1. Responses were entered into the computer by the subjects. They were instructed to complete as many trials as quickly and accurately as possible.

Profile of Mood States (POMS). Each day, subjects completed eight items which were drawn from the POMS (2). These items were selected because it has previously been suggested that they are sensitive to dietary manipulations and may be related to vigilance performance (3, 4). As shown in Figure 2, each item is rated on a five–point scale (0 = "not at all," 4 = "extremely").

Results and Discussion

Vigilance. Responses were partitioned in three categories: (1) target hits, (2) distractor hits, and (3) bad hits. These three categories were then expressed as percentages. Target hits occurred when the subject correctly identified a target. Distractor hits occurred when the subject responded to a distractor. Bad hits were defined as all other false alarms (i.e., any incorrect response that was not a distractor hit). Based on target hits and distractor hits, a nonparametric sensitivity measure, which is an estimate of area under the Receiver Operating Characteristic (ROC) curve, was calculated (5). Data were then pooled over blocks of seven days

for each week of the test. Analyses of variance (ANOVA) were then calculated separately for each of the four measures. Tables 1–4 show the mean values (± standard error) of each of the measures for both the RLW and MRE for all four weeks. No ration effects were significant while there was a main effect of time on percentage of target hits (Figure 3). Neuman–Keuls post hoc tests indicated that there was a significant decrease in percentage target hits between weeks 2 and 3. That is, both weeks 1 and 2 were different from both weeks 3 and 4. However, week 1 was not different from week 2, and week 3 was not different from week 4.

Encoding. Four dependent measures were taken: (1) number of trials completed, (2) percentage of words which were completely correct, (3) percentage of total letters which were incorrect, and (4) mean incorrect letters per word. Tables 5–8 show the mean values for each of the measures for both the RLW and MRE groups for all four weeks. Again, no ration effects were significant. However, there was a main effect of time on number completed and a time x ration interaction which are shown in Figure 4. The results of Neuman–Keuls post hoc tests were complex but indicated that number completed increased over time for both groups but more for the RLW group. In addition, there was a time x ration interaction for percentage of letters which were wrong (shown in Figure 5). Neuman–Keuls post hoc tests yielded no significant comparisons.

Profile of Mood States. Scores were summed across individual items for each day resulting in one score with a possible range of 0 to 32. These scores were then summed over seven day blocks creating four weekly means for both the RLW and MRE groups. As shown in Table 9, analysis of variance yielded nonsignificant main effects for both ration and time and a nonsignificant interaction. Thus, neither effects of ration nor time on mood states were found.

Conclusions

1. Overall performance was quite good in both the vigilance and encoding tasks. On the vigilance task, percentage of target hits ranged from approximately 66% to approximately 83%. False alarms, distractor hits and bad hits were very infrequent, approximately 3% and<1%, respectively. On the encoding task, percentage correct was usually over 90%.

2. No significant ration main effects were found.

3. Two significant main effects were found for time: (a) In the vigilance task, percentage target hits decreased over time, (b) In the encoding task, number completed increased over time (without a concomitant increase in errors) – this increase is probably due, for the most part, to the ration x time interaction discussed below.

4. Two significant time x ration interactions were found: (a) number completed in the encoding task, (b) percentage letters incorrect in the encoding task. The former is due to the increasing slope of the RLW function. This might be the result of the higher morale of the RLW group which was noted anecdotally by a number of the experimenters. The latter interaction results from a complex relationship among the variables and is probably not worth investigating further due to the very low error rates.

5. No significant main effects of ration or of time on daily mood scales were found.

REFERENCES

1. Smith, A., and Miles, C. The effects of lunch on cognitive vigilance tasks. Ergonomics, 29 (10): 1251–1261, 1986.

2. McNair, D.M., Lorr,M. and Droppleman, L.F. EITS manual for the Profile of Mood States (POMS). San Diego: Educational and Industrial Testing Service, 1981.Mood States, Educational and Industrial Testing Service, San Diego, California.

3. Spring, B.J., Lieberman, H.R., Swope, G., and Garfield, G.S. Effects of carbohydrates on mood and behavior. Nutrition Reviews, 44(Suppl.): 51–60, 1986.

4. Lieberman, H.R., Spring, B.J., and Garfield, G.S. The behavioral effects of food constituents: strategies used in studies of amino acids, protein, carbohydrate and caffeine. Nutrition Reviews, 44(Suppl.): 61–70, 1986.

5. Pollack, I., and Norman, D.A. A nonparametric analysis of recognition experiments. Psychonomic Science, 1: 125–126, 1964.

Footnote

1. Due to several hardware failures, small amounts of data were lost. Subjects with incomplete data for a particular analysis were not included in that analysis.

Table 1

Vigilance Task

Percentage Target Hits (mean ± SE)

	RLW	MRE
Week 1	76.10 ± 5.25	83.07 ± 2.57
Week 2	74.88 ± 6.59	81.73 ± 3.59
Week 3	63.87 ± 6.61	78.02 ± 4.15
Week 4	65.93 ± 7.09	76.10 ± 5.28

Effect	F	p
Ration	2.06	.161
Week	5.45	.002*
Ration x Week	0.75	.523

Table 2

Vigilance Task

Percentage Bad Hits (mean ± SE)

	RLW	MRE
Week 1	0.17 ± 0.07	0.13 ± 0.03
Week 2	0.19 ± 0.07	0.11 ± 0.04
Week 3	0.20 ± 0.08	0.11 ± 0.05
Week 4	0.12 ± 0.03	0.09 ± 0.02

Effect	F	p
Ration	0.87	.359
Week	1.74	.165
Ration x Week	0.65	.585

Table 3

Vigilance Task

Percentage Distractor Hits (mean ± SE)

	RLW	MRE
Week 1	2.89 ± 0.93	3.91 ± 1.51
Week 2	2.61 ± 0.66	2.93 ± 1.31
Week 3	2.35 ± 0.58	2.28 ± 1.28
Week 4	2.73 ± 0.73	2.82 ± 1.58

Effect	F	p
Ration	0.05	.828
Week	1.55	.208
Ration x Week	0.45	.717

Table 4

Vigilance Task

Sensitivity (mean ± SE)

	RLW	MRE
Week 1	0.92 ± 0.02	0.94 ± 0.01
Week 2	0.90 ± 0.03	0.94 ± 0.01
Week 3	0.90 ± 0.02	0.93 ± 0.01
Week 4	0.90 ± 0.02	0.92 ± 0.02

Effect	F	p
Ration	1.78	.192
Week	1.68	.177
Ration x Week	0.39	.762

Table 5

Encoding Task

Number Completed (mean ± SE)

	RLW	MRE
Week 1	32.00 ± 1.96	33.38 ± 2.00
Week 2	37.62 ± 2.62	30.06 ± 1.74
Week 3	39.00 ± 3.04	35.63 ± 2.33
Week 4	41.00 ± 3.22	37.00 ± 2.73

Effect	F	p
Ration	1.02	.321
Week	25.75	.000*
Ration x We	9.99	.000*

Table 6

Encoding Task

Percentage Correct (mean ± SE)

	RLW	MRE
Week 1	90.59 ± 1.49	92.23 ± 1.18
Week 2	91.91 ± 1.77	89.75 ± 1.57
Week 3	92.40 ± 1.81	91.71 ± 0.91
Week 4	91.26 ± 1.67	90.78 ± 1.10

Effect	F	p
Ration	0.06	.802
Week	0.64	.589
Ration x Week	1.35	.265

Table 7

Encoding Task

Percentage Letters Incorrect (mean ± SE)

	RLW	MRE
Week 1	2.88 ± 0.67	1.90 ± 0.33
Week 2	1.90 ± 0.43	3.01 ± 0.67
Week 3	1.75 ± 0.40	2.10 ± 0.27
Week 4	2.29 ± 0.49	2.25 ± 0.29

Effect	F	p
Ration	0.06	.814
Week	0.77	.512
Ration x Week	2.69	.052*

Table 8

Encoding Task

Mean Letters Incorrect/Incorrect Word (mean ± SE)

	RLW	MRE
Week 1	1.28 ± 0.06	1.18 ± 0.05
Week 2	1.16 ± 0.04	1.28 ± 0.06
Week 3	1.18 ± 0.05	1.22 ± 0.05
Week 4	1.30 ± 0.11	1.20 ± 0.06

Effect	F	p
Ration	0.04	.849
Week	0.26	.850
Ration x Week	1.87	.141

Table 9

Profile of Mood States

Total Score (mean ± SE)

	RLW	MRE
Week 1	19.12 ± 2.08	15.65 ± 1.50
Week 2	19.30 ± 1.99	14.52 ± 1.64
Week 3	17.71 ± 2.08	14.53 ± 1.70
Week 4	16.38 ± 2.02	15.42 ± 2.00

Effect	F	p
Ration	1.61	.216
Week	1.34	.268
Ration x Week	1.76	.162

FIGURE LEGENDS

Figure 1. Trigraph codes.

Figure 2. Profile of mood states (POMS) questionnaire.

Figure 3. RLW–30 vs MRE groups, percentage of target hits.

Figure 4. RLW–30 vs MRE groups, encoding, number completed.

Figure 5. RLW–30 vs. MRE groups, encoding, percent letters incorrect.

A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
B	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z
C	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y
D	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X
E	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W
F	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V
G	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U
H	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T
I	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S
J	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R
K	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q
L	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P
M	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O

N	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	M	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N
O	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	L	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M
P	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	K	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L
Q	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	J	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K
R	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	I	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J
S	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	H	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I
T	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	G	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H
U	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	F	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G
V	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	E	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F
W	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	D	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E
X	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	C	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D
Y	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	B	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C
Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	A	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B

FIGURE 1

DATE: _____ TIME: _____

HOW ARE YOU FEELING TODAY?

	NOT AT ALL	A LITTLE	MODERATELY	QUITE A BIT	EXTREMELY
LIVELY	0	1	2	3	4
ACTIVE	0	1	2	3	4
ENERGETIC	0	1	2	3	4
CHEERFUL	0	1	2	3	4
ALERT	0	1	2	3	4
FULL OF PEP	0	1	2	3	4
CAREFREE	0	1	2	3	4
VIGOROUS	0	1	2	3	4

FIGURE 2

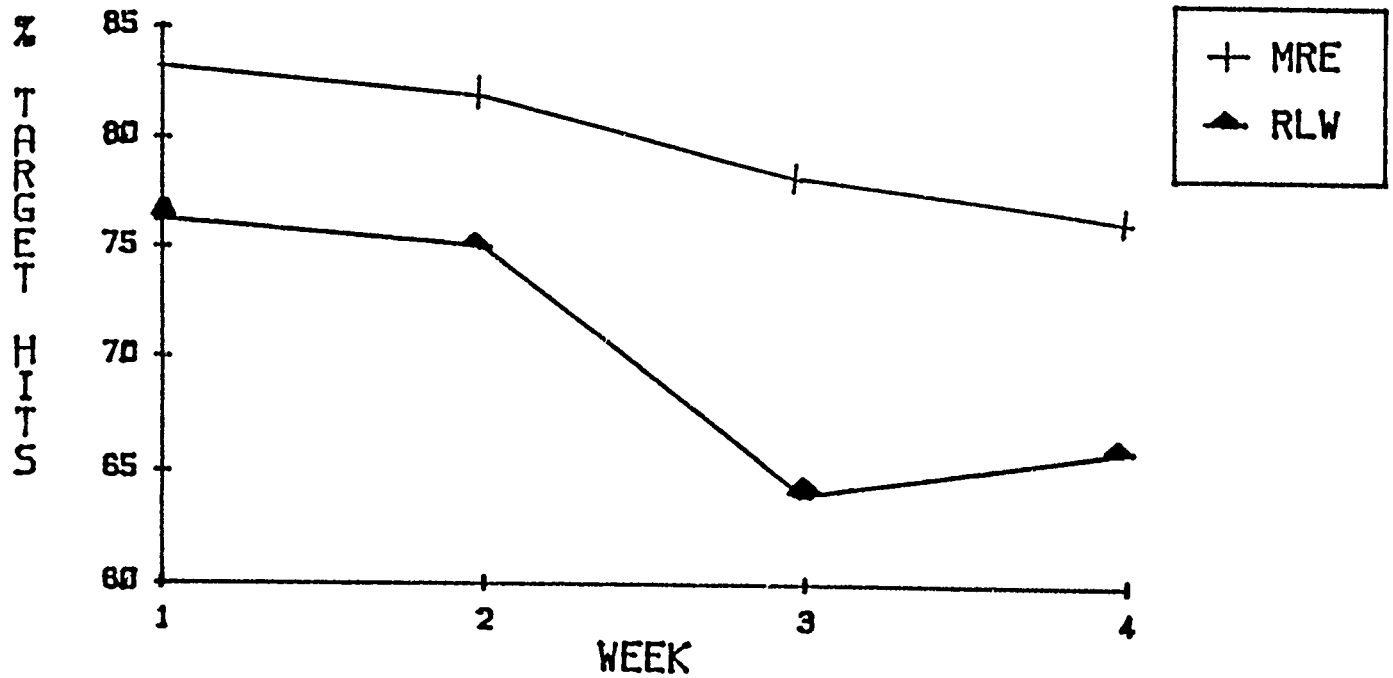

RLW VS MRE
PERCENTAGE OF TARGET HITS
% TARGET HITS
85
80
75
70
65
60
1
2
3
4
WEEK
MRE
RLW

FIGURE 3

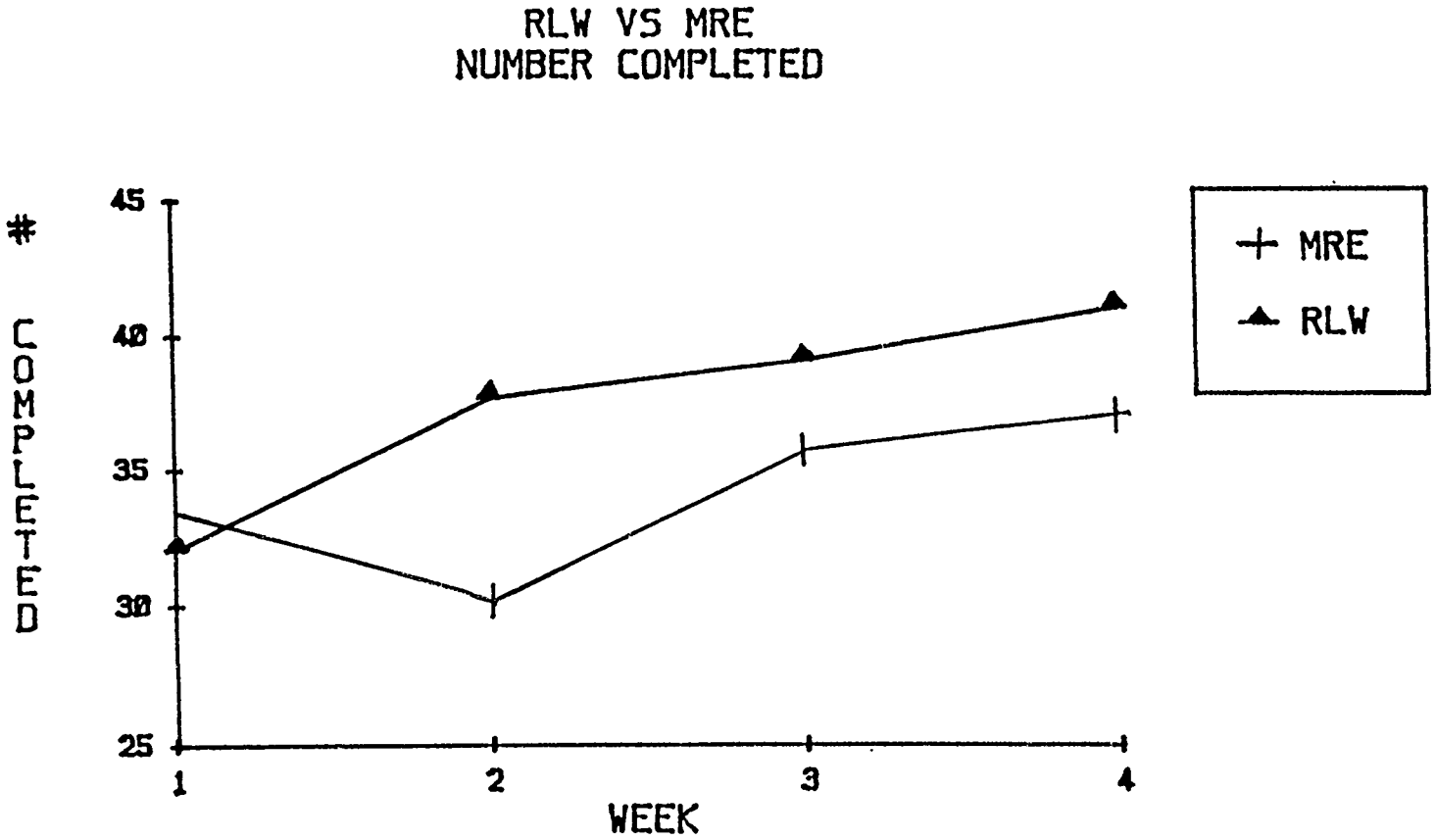

RLW VS MRE
NUMBER COMPLETED
COMPLETED
45
40
35
30
25
1
2
3
4
WEEK
MRE
RLW

FIGURE 4

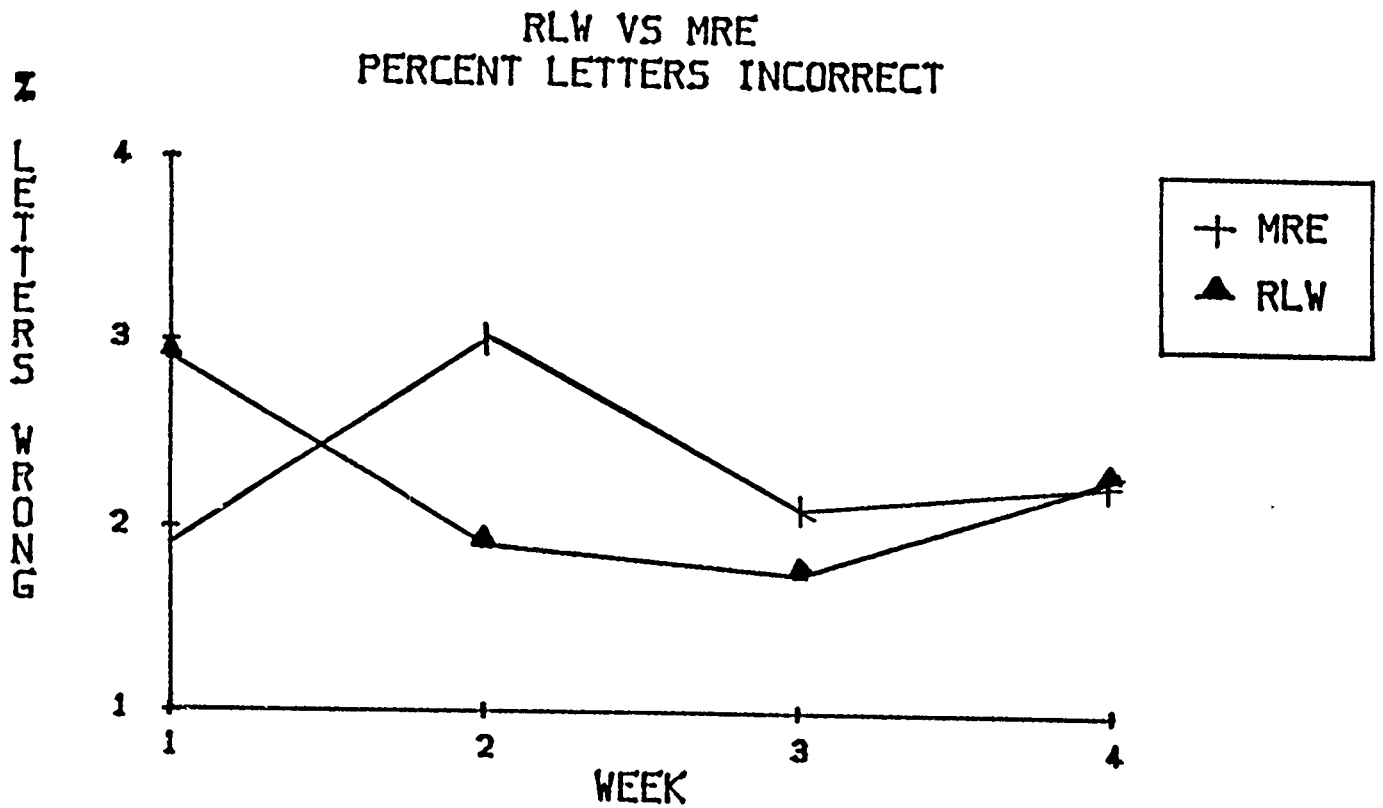

RLW VS MRE
PERCENT LETTERS INCORRECT
% LETTERS WRONG
4
3
2
1
1
2
3
4
WEEK
MRE
RLW

FIGURE 5

MEDICAL EVALUATION, PHYSICAL EXAM, BLOOD and URINE CHEMISTRIES

MEDICAL EVALUATION, PHYSICAL EXAM, AND BLOOD AND URINE CHEMISTRIES

Methods

Test subjects were screened for cardiopulmonary, renal, gastrointestinal and endocrine disorders prior to initiation of the testing. This was accomplished by medical interview and examination by a physician and laboratory screening. The laboratory screening tests were all performed using standard clinical medical laboratory techniques at Cutler Army Hospital, Ft. Devens, Massachusetts. They included an automated CBC, urinalysis, T3, T4, TSH, serum electrolytes, cholesterol, triglyceride, amylase and liver enzymes.

Individuals were monitored at weekly intervals throughout the testing period for weight loss (or gain) and development of symptoms referable to rations. Their hydration status was assessed on a regular basis by measuring blood pressures, urine specific gravities and analyzing urine osmolalities. At the completion of testing, individuals were again medically screened by medical history, physical exam and laboratory testing. Repeated CBC, urinalysis and serum chemistries were obtained. A 24 hr creatinine clearance was also performed.

Results

All study participants had negative histories, normal physical exams and pre-study laboratory screens. The lab results included serum electrolytes, CBC, urinalysis, T3, T4, TSH, serum cholesterol, triglycerides, liver enzymes and amylase (Blood chemistries are shown in Table 1). It should be noted that consuming the 47% fat (Of the kcal) RLW-30 ration did not increase serum cholesterol. This was probably due to the hypocaloric nature of the ration. Fat intakes were only 100 g/man/day.

During the study, eight members of the RLW-30 group complained of light headedness or dizziness particularly in the last few weeks of the study. Blood pressures taken throughout the study revealed a decrease in systolic pressures in the RLW-30 group in the 2nd week but they approached baseline over the following week (Table 2). The significance of this decrease is uncertain since a similar decrease was noted for the MRE group, although the MRE group did not return to baseline. Fluid intake was adequate and normal orthostatic measurements, specific gravities and urine osmolalities were observed (refer to Table 6 in the Nutrition and Hydration Status sub-section). Blood pressures can vary with the respiratory cycle but this was unlikely in this case in which there were such consistent differences noted between the MRE and RLW-30 groups. Another consideration would be fluid volume depletion, but orthostatic measurements and laboratory results revealed adequate hydration for both groups. Low blood pressures have been ascribed to low blood sugar levels in semistarvation studies (2), however the MRE group was not in semistarvation. Low blood sugar is also consistent with the presence of ketones in the urine and symptoms of dizziness, decrease in concentration and paresthesias noted in the RLW-30 group. However, it is very difficult to diagnose hypoglycemia without performing frequent blood sugars. Also, it has been shown that the nutritional state of the subject may have a definite influence on the occurrence of symptoms in relationship to the changes of blood sugar (2). Although direct evidence of a carbohydrate inadequacy is lacking, the results of this study suggest that it might be prudent to reassess the amount of carbohydrate in the RLW-30 ration. Other symptoms noted during the test included easy fatigability and generalized weakness which were noted in eight subjects in the RLW-30 group and none of the MRE group. This was not reflected in their performance on the physical performance test

(refer to Table 5 in sub-section on Muscle Strength and Endurance, Aerobic Capacity and Body Composition).

Three subjects from the RLW-30 group reported decreased alertness or difficulty with concentrating on details, which was reflected in the mental and psychological studies comparing the MRE and RLW-30 groups (refer to sub-section on Symptoms, Mood States and Performance). Other associated symptoms reported included paresthesias of the hands or feet which were particularly noted in the last week of testing. However, neurological examination revealed no neuropathic changes.

Several subjects in the RLW group reported microscopic hematuria on their dipstick measurements during the last two weeks of the study but when repeated on a urinalysis by the Cutler Hospital Laboratory the hematuria was not present. Six subjects of the RLW-30 and three subjects of the MRE group reported 1+ proteinuria on the post exam urinalysis. There was no evidence of hypoalbuminemia or edema in either of the two test groups and the 24 hour creatinine clearance collections are pending analyses. Trace to small quantities of urinary ketones were noted on the dipsticks of the RLW-30 group (Refer to sub-section on Nutritional and Hydration Status).

A significant number of the RLW-30 group reported non-bloody loose, watery stools. The stools were not foul nor copious. With the exception of one subject, they denied flatulence, cramping, nausea, vomiting and fever.

One subject was removed from the study after three weeks. During the first week he had complained of light headedness on standing but orthostatic measurements were unremarkable and his fluid intake was sufficient. The second week he reported loose non-foul, non-bloody stools and mild lower abdominal cramping with nausea but no vomiting. He also noted subjective fever and mild frontal headaches with

some difficulty with concentrating on details. Physical examination revealed normal vital signs including absence of orthostasis, no evidence of colitis or appendicitis or other acute findings. His cardiopulmonary and neurological exam was completely normal including absence of meningeal signs and papilledema. Body weight measurements revealed that he lost 5 lbs which was 3.7% of his original body weight. Blood chemistries were repeated which included liver enzymes, amylase, electrolytes, calcium and magnesium and found to be normal. A urine dipstick revealed ketosis but a normal specific gravity. The CBC with differential, and the sedimentation rate were normal. Stool samples for analysis of bacteriologic and parasitic pathology were negative. It was surmised that his symptoms were not directly related to the rations themselves but possibly to insufficient calories. Therefore, his rations were doubled for week 3 (4000 kcal/day). The third week he reported flatulence and abdominal pain with persistent diarrhea, hair loss and apathy. His physical exam remained normal. He was removed from the study because of progressive symptoms. He continued to note diarrhea and generalized weakness while on a regular diet. He underwent an extensive evaluation at Cutler Hospital, Ft. Devens which included an upper GI series, barium enema and multiple examinations of the stool for leukocytes, enteric pathogens and parasites. Cultures of the stool revealed only decreased bowel flora and the radiographic studies showed a prominent mucosal pattern in the small bowel. Blood serology revealed a negative HTLV III. The subject was then referred to a gastroenterologist for further evaluation. Upper and lower endoscopic studies with biopsies were performed and found to be negative. Studies for malabsorption including the D-xylose and stool fat analysis were normal. He was then empirically treated with metronidazole and after no improvement was switched to doxycycline as well as a deletion diet. Over the next few weeks, after treatment with doxycycline,

some clinical improvement was noted. His symptoms gradually resolved and some of the lost weight was regained. A definitive diagnosis was not made. However, there was no evidence to indicate a direct ill-effect from the ration from an infectious, toxic or nutritional standpoint.

Overall, the RLW-30 subjects resumed their normal diets at the completion of the study without problems with exception of the subject mentioned earlier and another subject who experienced post prandial nausea and vomiting when he began a high bulk diet. This intolerance was thought to be secondary to a change in diet from a low bulk RLW-30 diet.

One subject from the MRE group developed a vascular headache and chest discomfort during the field exercise in the second week of the study. After close observation and full evaluation by specialists including a neurologist, it was postulated that he had suffered from heat exhaustion. He was continued on the rations and encouraged to maintain adequate fluid intake. He eventually resumed the field exercises when he was medically cleared and did not encounter any further problems.

One subject from the RLW-30 group was unable to complete the physical performance testing at the end of the test period because he had sustained an ankle sprain during a rucksack march while in the field.

Conclusions

1. There were no significant symptoms noted in the MRE group.

2. Several subjects experienced diarrhea while on the RLW-30 ration. There was no physical evidence of toxic or infectious etiology. Prior to the study, the rations were very thoroughly screened for enteric pathogens and the low water content of the rations themselves precludes the possibility of parasitic contamination unless the

subjects used contaminated water from an outside source to hydrate the rations. It has been shown radiographically and histologically that digestive processes can be affected when nutritional states are altered (2). However, there was no evidence of malabsorption among the RLW-30 group. Finally, it has been shown that when one consumes a large amount of water and mixes an additional amount with the food this can lead to diarrhea (1). This may be the reason for the reports of loose stools in the RLW-30 group since they consumed a liter of fluid more/day than the MRE group (Refer to sub-section on Water Intakes and Fluid Consumption Patterns).

3. One subject became ill in the RLW-30 group requiring subsequent hospitalization to determine the etiology of his illness. A final diagnosis was not made but he may possibly have contaminated his ration with water from an outside source.

4. Overall, the subjects resumed their normal diets without difficulty with the exception of one subject whom consumed a high bulk diet prematurely. It is important to educate the soldiers about resuming their diets after being placed on diets of a different nutritive status.

5. Microscopic hematuria was noted in several of the subjects in the RLW-30 group when urines were checked with Ames strips by the subjects themselves. When repeated in the laboratory there was no hematuria. Therefore, the hematuria was either transient or a false positive result of the dipstick method.

6. Proteinuria was noted by several RLW-30 subjects and a few in the MRE group. The clinical significance of this finding is uncertain. Renal disease has been reported in semistarvation studies but in a majority of cases such patients were severely malnourished and dehydrated (2). Further evaluations are pending including the 24 hour creatinine clearance collections.

7. A physical examination before and after the 30 day FTX revealed that both groups of subjects were in satisfactory physical condition with the exception of the subject mentioned in (3) above.

REFERENCES

1. Davenport, Horace W. Physiology of the Digestive Tract, Year Book Medical Publishers, Chicago 3rd edition pp. 212–213, 1975.

2. Keys, Ancel, J. Brozek, A. Henchel, O. Mickelsen, H.L. Taylor The Biology of Human Starvation The Univ of Minnesota Press, Minneapolis, Volume 1 p. 557–561; 184–197; 587–600; 664–674, 1950.

Table 1. Blood Chemistries Pre and Post 30 Day FTX[1]

Chemistry	Ration Group MRE Pre	MRE Post	RLW-30 Pre	RLW-30 Post	Normal Range
Glucose, mg/dl	91.9±1.7	88.2±2.0	95.8±2.5	89.3±1.0*	77–116
Triglycerides, mg/dl	95.9±7.7	220.2±37.8*[4]	103.8±10.8	88.1±6.3[3]	12–225
Cholesterol, mg/dl	190.1±8.2	190.5±6.4	187.7±8.4	187.5±4.6	170–260
Total protein, g/dl	6.95±0.07	7.06±0.07	6.93±0.08	7.24±0.11*	6.4–7.9
Albumin, g/dl	4.60±0.06	4.35±0.06*	4.43±0.04[2]	4.54±0.07[3]	4.1–5.1
Globulin, g/dl	2.35±0.06	2.72±0.06*	2.50±0.06	2.74±0.07*	1.3–3.0
AG Ratio	1.98±0.07	1.59±0.05*	1.79±0.05[2]	1.65±0.05*	1.4–2.7
Creatinine, mg/dl	1.14±0.02	1.24±0.03*	1.16±0.03	1.36±0.04*[3]	0.9–1.4
ALK Phosphate, u/L	53.8±2.8	58.4±3.1	55.0±2.8	53.4±3.7	29–92
SGOT, u/L	23.3±1.6	19.0±1.3*	21.2±2.2	18.9±1.0	7–32
Amylase, u/L	60.2±2.8	78.4±5.8*	71.6±7.0	81.3±8.0	25–115
Bilirubin, mg/dl	0.89±0.08	0.48±0.04*	0.89±0.09	0.80±0.13[3]	0.1–1.3

[1] Blood chemistries represent $\bar{x}$±SEM for 17 men/group

* Significantly different, $p<0.05$ Pre vs Post within ration groups.

[2] Significantly different, $p<0.05$ Pre vs Pre between ration groups.

[3] Significantly different, $p<0.05$ Post vs Post between ration groups.

[4] Post value for Triglycerides for MRE group is elevated primarily due to 3 individual elevated values of 623, 558, and 330 mg/dl.

Table 2. Blood Pressure Readings Taken Pre, Weekly, and Post 30 Day FTX[1]

Blood Pressure Component		Pre	Week 1	Week 2	Week 3	Post
Systolic	MRE	125±2	127±3	118±1	121±2	115±2
	RLW	128±2	121±2	118±2	120±2	121±3
Diastolic	MRE	82±1	74±2	80±2	78±2	73±2
	RLW	83±2	79±2	77±2	81±2	88±2
Mean Arterial Pressure[2]	MRE	96±1	91±2	93±1	92±2	87±2
	RLW	98±1	93±2	90±2	94±2	99±2

[1] Values shown are the $\bar{x}$±SEM for 17 subjects per group.

[2] Mean Arterial Pressure = Diastolic Pressure + 1/3 (Systolic Pressure − Diastolic Pressure). There was no significant main effect due to diet on Mean Arterial Pressure, but there was a significant ($p<0.05$) main effect due to time.

RATION ACCEPTANCE, HUMAN FACTORS ASSESSMENT, AND SUBJECTIVE PERFORMANCE RATINGS

RATION ACCEPTANCE, HUMAN FACTORS ASSESSMENT, AND SUBJECTIVE PERFORMANCE RATINGS

I. Final Questionnaire Data

Methods

At the completion of the test, subjects in both groups were asked to complete a questionnaire. The questionnaire was designed to address issues of ration acceptance, human factors, and subjective performance ratings. Acceptance was measured using the nine-point scale (1 = "dislike extremely," 9 = "like extremely") developed by Peryam and Girardot (1).

Results and Discussion

Acceptance. For the RLW group (Appendix 9, Table 4), all items were found to be acceptable (i.e., hedonic rating greater than 5) except the Lemonade Beverage Bar (4.82) and the Lemon-Lime Beverage Bar (4.29). Mean ratings were 6.99 for the Entrees, 6.45 for the Bread Bars, 7.91 for the Cereal Bars, 7.92 for the Desserts, 7.62 for the Dairy Bars, and 5.73 for the Drinks. Tabasco received a mean rating of 8.33. For the MRE group (Appendix 10, Table 4), all items were found to be acceptable except the Ham/Chicken Loaf (2.44), the Fruitcake (3.94), the Orange Nut Cake (3.25), and the Pineapple Nut Cake (4.13). The mean acceptance rating across all items of the RLW (6.83) was not significantly different from that of the MRE group (6.53), $p>0.05$.

Subjective Ratings of Performance. When asked "How do you feel that this ration affected your overall performance?" the mean rating for RLW subjects was 5.24 (Appendix 9, Table 5), while it was 4.55 for the MRE subjects (Appendix 10, Table 5)

on a seven-point scale (1 = "extremely positive effect," 7 = "extremely negative effect"). These means were not significantly different from each other ($P>0.05$).

When subjects were asked "If you had only this ration to eat, in combat, how many more days would it have sustained you?", the modal response (29.4%) was 0 for the RLW group (Appendix 9, Table 6) while it was "indefinitely" (33.3%) for the MRE group (Appendix 10, Table 6). This result should be viewed with some caution since the RLW subjects knew that the ration was designed to sustain them for 30 days. It is interesting to note that this is essentially the same result as was found in the 12 day test of the RLW-30 at Fort Chaffee (2). For that study, the mean response was 14.64 days. Thus, in both studies the subjects report being able to last 30 days on the ration which they know was designed for 30 days. This is likely to be due somewhat to the demand characteristics of the situation. For future testing of similar or the same rations, it might be best to use a name which elicits fewer demand characteristics.

Desired changes to the rations. 70.6% of the RLW subjects (Appendix 9, Table 7) felt that the most important change to the ration was that it should be "more filling," the second most important change was "more variety," the third most important change was "less rehydrating," the fourth most important change was "be lighter," and the fifth most important change was "take up less space." For the MRE group (Appendix 10, Table 7), the most desired change (55.6%) was "take up less space," the second most was "be lighter," the third most was "be more filling," the fourth was "taste better," and the fifth was "cause less thirst." These data are especially interesting because while the RLW subjects felt that the ration needed to be more filling, the MRE subjects, too, (with three MREs available per day) felt that their ration needed to be more filling.

Ration Design. The RLW subjects (Appendix 9; Table 8) were asked to design a ration (i.e., determine the number of bars of each type) from the same components with the same number of components as the RLW. Not one subject included a Fruit Beverage Bar. This presents an interesting contrast to the data of the 12 day test (2) where subjects wanted 1.42 (SD = 0.66) Fruit Beverage Bars per day. Slight increases in number were desired in the Entree Bars, Dairy Bars, and Cereal Bars.

When RLW subjects were asked whether they feel the ration should have more calories despite the fact that it would be heavier and take up more space, the mean response on a five-point scale (1 = "disagree strongly," 5 = "agree strongly") was 4.12.

Hunger. When subjects were asked "Overall, did you get enough to eat or were you hungry?", the mean response for RLW subjects (Appendix 9, Table 22) on a four-point scale (1 = "got enough to eat," 4 = "was almost always hungry"), 3.29 was significantly greater than the mean response of the MRE group (Appendix 10, Table 21), 1.78, $p<0.001$.

When asked why they did not eat enough, 82.4% of RLW subjects responded "not enough rations," 11.8% responded "always ate enough," and 5.9% responded "not enough time." When the MRE subjects were asked the same question, 38.9% responded "disliked the rations," 38.9% responded "always ate enough," 33.3% responded "not enough rations," and 5.6% responded "not enough time."

Convenience. When subjects were asked to rate "convenience/ease of use" on a five-point scale (1 = "extremely convenient," 5 = "extremely inconvenient"), no significant difference was found between the means of the groups, 2.25 and 2.72, for the RLW (Appendix 9, Table 24) and MRE (Appendix 10, Table 23) groups, respectively, $p>0.05$.

Subjective ratings of important factors for combat rations. Subjects were asked to rank order the importance of five characteristics of combat rations. For both the RLW (Appendix 9, Table 30) and the MRE (Appendix 10, Table 27), the order from most important to least important was: (1) "Light weight," (2) "Gives me enough energy to do my job," (3) "Takes up little space," (4) "Stops my hunger," and (5) "Tastes good." The consistency between the two groups on this question is interesting since one might expect the subjects' experience on the field test to affect their responses to this question.

Both the RLW (Appendix 9, Table 27) and the MRE (Appendix 10, Table 24) groups were asked to rate the ration on the above factors using a 4-point scale (1 = "excellent," 4 = "poor"). For the most important factor, "lightweight," the mean of the RLW group, 1.41, was significantly lower than the mean of the MRE group, 3.39, $p<0.001$. For the second most important factor, "gives me enough energy to do my job," there was no significant difference between the mean of the RLW group, 3.29, and the mean of the MRE group, 2.61, $p>0.05$. For the third most important factor, "takes up little space," the mean of the RLW group, 1.65, was significantly lower than the mean of the MRE group, 3.67, $p <0.05$. For the fourth most important factor, "stops my hunger," the mean of the RLW group, 3.71, was significantly greater than the mean of the MRE group, 2.67, $p<0.001$. For the fifth most important factor, "tastes good," the mean of the RLW group, 1.53, was significantly lower than the mean of the MRE group, 2.94, $p<0.001$. In summary, the RLW was rated as more lightweight, more low-volume, better tasting, and less filling than the MRE. However, no difference was found in the subjects' rating of "energy."

Variety. The RLW subjects were asked to rate how satisfied they were with the variety of each ration component on a four-point scale (1 = "enough variety," 4 =

"should have much more variety"). For all components, lack of variety did not seem to be a problem with 2.19 the highest mean rating (Crispy Bread Bars).

II. Daily Log Book Data

Methods

Each subject carried a pocket sized log book in which he recorded daily what he ate and how much he liked it using a nine-point hedonic scale (1). Subjects were provided with new log books weekly after turning in the ones they used the previous week. Samples of the log books can be found in Appendix 3.

Results and Discussion

Acceptance. For the RLW group, each ration component was placed in one of six categories: Beverage Bars, Dairy Bars, Entree Bars, Cereal Bars, Bread Bars, and Dessert Bars. Data were then pooled for each category over weeks of the test. Mean acceptance is shown as a function of week in Figure 1 (means and standard errors are shown in Table 1). No trends over time are apparent. Acceptance of all items was stable with no item varying no more than approximately 0.6 on the hedonic scale over the course of the test, except for the Dessert Bars whose acceptance took an unexplained dip during week 2.

For the MRE group, each ration component was placed in one of seven categories: Entree Bars, Starch, Spreads, Fruit, Dessert, Beverage, and Other. Data were then pooled as above. Mean acceptance is shown as a function of week in Figure 2 (means and standard errors are shown in Table 2). Again, no trends over time are apparent. Acceptance of all items was stable with no item varying more than approximately 0.5 on the hedonic scale over the course of the test.

Satiety. After dinner each day, subjects were asked to answer the following question, "If +100 is the fullest you can imagine, and -100 is the hungriest, how full or hungry are you now?" Mean satiety ratings were taken for each group for each day and are plotted as a function of day in Figure 3. Note that the function for the MRE group is relatively flat while the function for the RLW group drops precipitously. There is some scalloping to the function due probably to resupply of the rations after each week. While the RLW group is more "hungry" than the MRE group from the first day of the test, they do not actually report being "hungry" (i.e., negative ratings) until day 7. At the end of week 4, the mean satiety rating for the MRE group is approximately +70 while it is approximately -50 for the RLW group. This difference seems to be larger than would be expected based on the caloric intake and weight loss data and therefore, is probably due partially to the much smaller volume of the RLW-30.

Conclusions

1. The RLW-30 is a very well accepted ration. It was rated no worse, and perhaps better, than the control MRE. However, subjects reported being quite "hungry" probably due, in part, to the small volume they were consuming.

2. No major human factors problems were identified. However, the large amount of water used with the ration may pose a human factors problem if pickup water or time available for rehydration of rations is limited.

3. There was no significant difference between the RLW and MRE groups in their perception of their ration's affect on their performance. However, when asked how many more days they could sustain, the RLW group responded 0 while the MRE group responded "indefinitely." This may be due somewhat to the demand characteristics of the test situation but might also result in a problematic self-fulfilling prophecy.

REFERENCES

1. Peryam, D.R., and Girardot, N.F. Advanced taste-test method. Food Engineering. 194: 58-61, 1952.

2. Siegel, S.F., Poole, P.M., Askew, E.W., Kinney, M.A., Shaw, C., Aylward, J., and Hunter, S. Twelve day field test of Ration Lightweight, 30 Day at Fort Chaffee, Arkansas. Unpublished manuscript.

FOOTNOTES

1. Complete results may be found in Appendix 9 for the RLW group and Appendix 10 for the MRE group. Appropriate tables are listed in the text.

2 Complete results may be found in Appendix 11 for the RLW group and Appendix 12 for the MRE group.

Table 1

RLW GROUP

ACCEPTANCE

	WEEK 1		WEEK 2		WEEK 3		WEEK 4	
	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
BEVERAGE BAR	7.28	0.12	7.66	0.09	7.44	0.11	7.26	0.09
DAIRY BAR	7.33	0.19	7.71	0.11	7.89	0.11	7.60	0.11
ENTREE BAR	7.50	0.13	7.94	0.08	7.68	0.12	7.48	0.09
CEREAL BAR	6.96	0.13	7.29	0.10	7.38	0.11	7.29	0.10
BREAD BAR	7.47	0.22	6.89	0.18	7.13	0.18	7.00	0.14
DESSERT BAR	7.88	0.12	7.00	0.09	8.00	0.11	7.70	0.10

Table 2

MRE GROUP

ACCEPTANCE

	WEEK 1		WEEK 2		WEEK 3		WEEK 4	
	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
ENTREE	6.69	0.10	7.01	0.10	7.23	0.16	7.05	0.09
STARCH	6.85	0.11	6.99	0.11	7.09	0.11	7.01	0.10
SPREADS	6.96	0.12	7.29	0.11	7.38	0.13	7.29	0.11
FRUIT	7.40	0.16	7.71	0.13	7.73	0.14	7.38	0.13
DESSERT	6.86	0.14	7.37	0.11	7.23	0.15	7.08	0.13
BEVERAGE	7.52	0.08	7.71	0.07	7.85	0.08	7.47	0.08
OTHER	7.51	0.18	7.08	0.17	7.45	0.16	7.34	0.17

FIGURE LEGENDS

Figure 1. Weekly mean acceptance of RLW-30 ration components.

Figure 2. Weekly mean acceptance of MRE ration components.

Figure 3. Daily mean ration group hunger ratings.

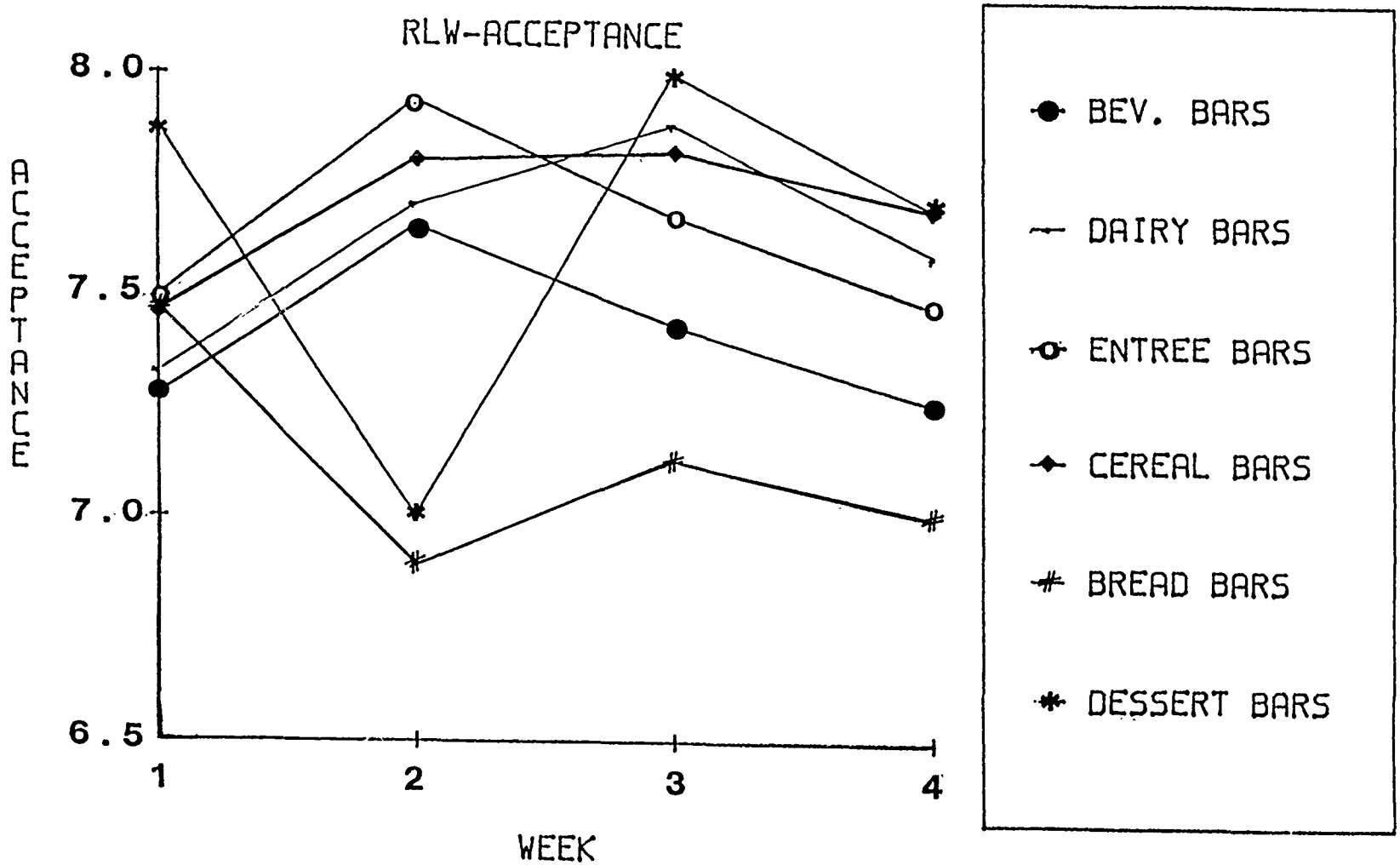

RLW-ACCEPTANCE
8.0
7.5
7.0
6.5
ACCEPTANCE
1
2
3
4
WEEK
BEV. BARS
DAIRY BARS
ENTREE BARS
CEREAL BARS
BREAD BARS
DESSERT BARS

FIGURE 1

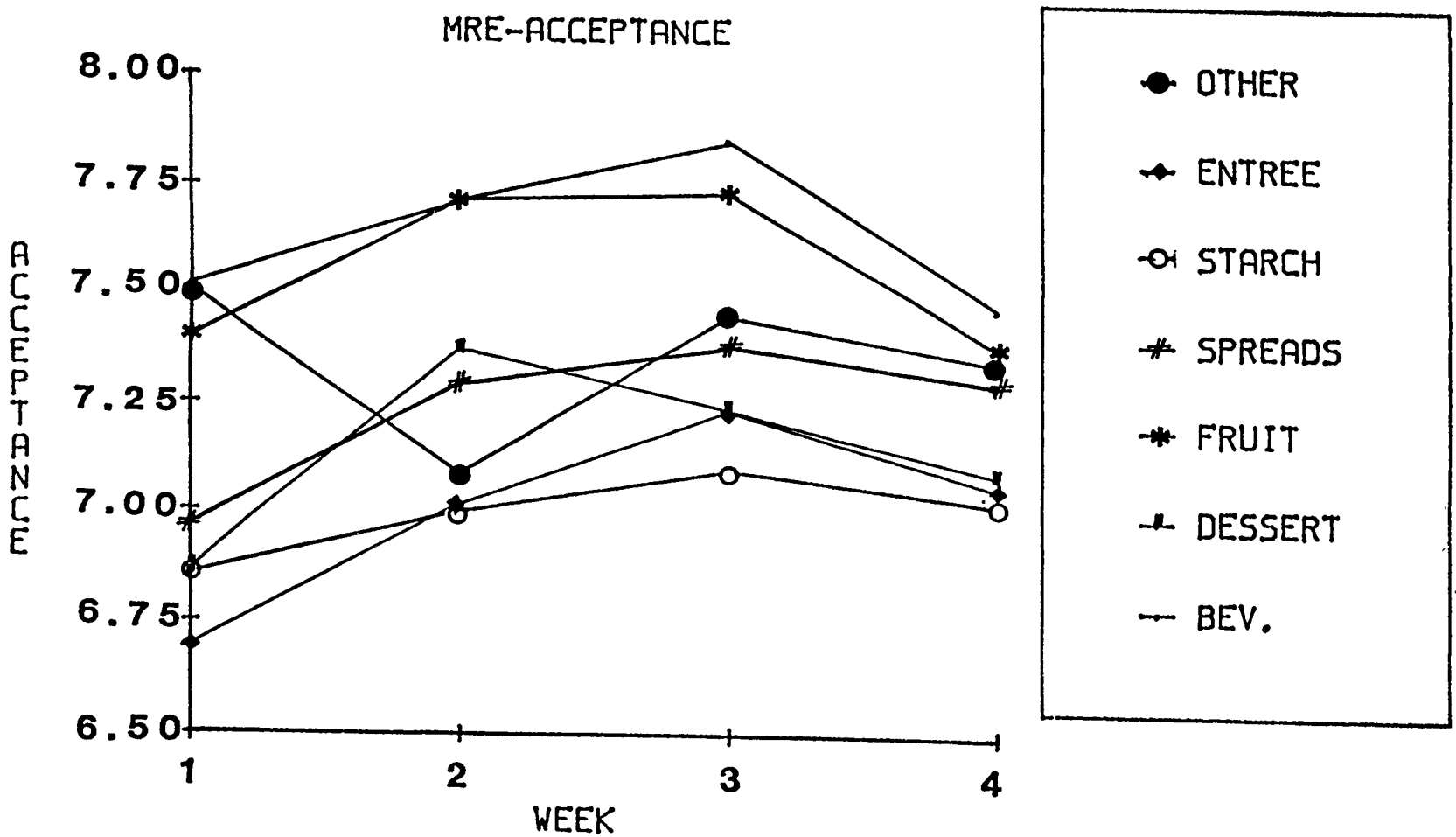

MRE-ACCEPTANCE
8.00
7.75
7.50
7.25
7.00
6.75
6.50
ACCEPTANCE
1
2
3
4
WEEK
OTHER
ENTREE
STARCH
SPREADS
FRUIT
DESSERT
BEV.

FIGURE 2

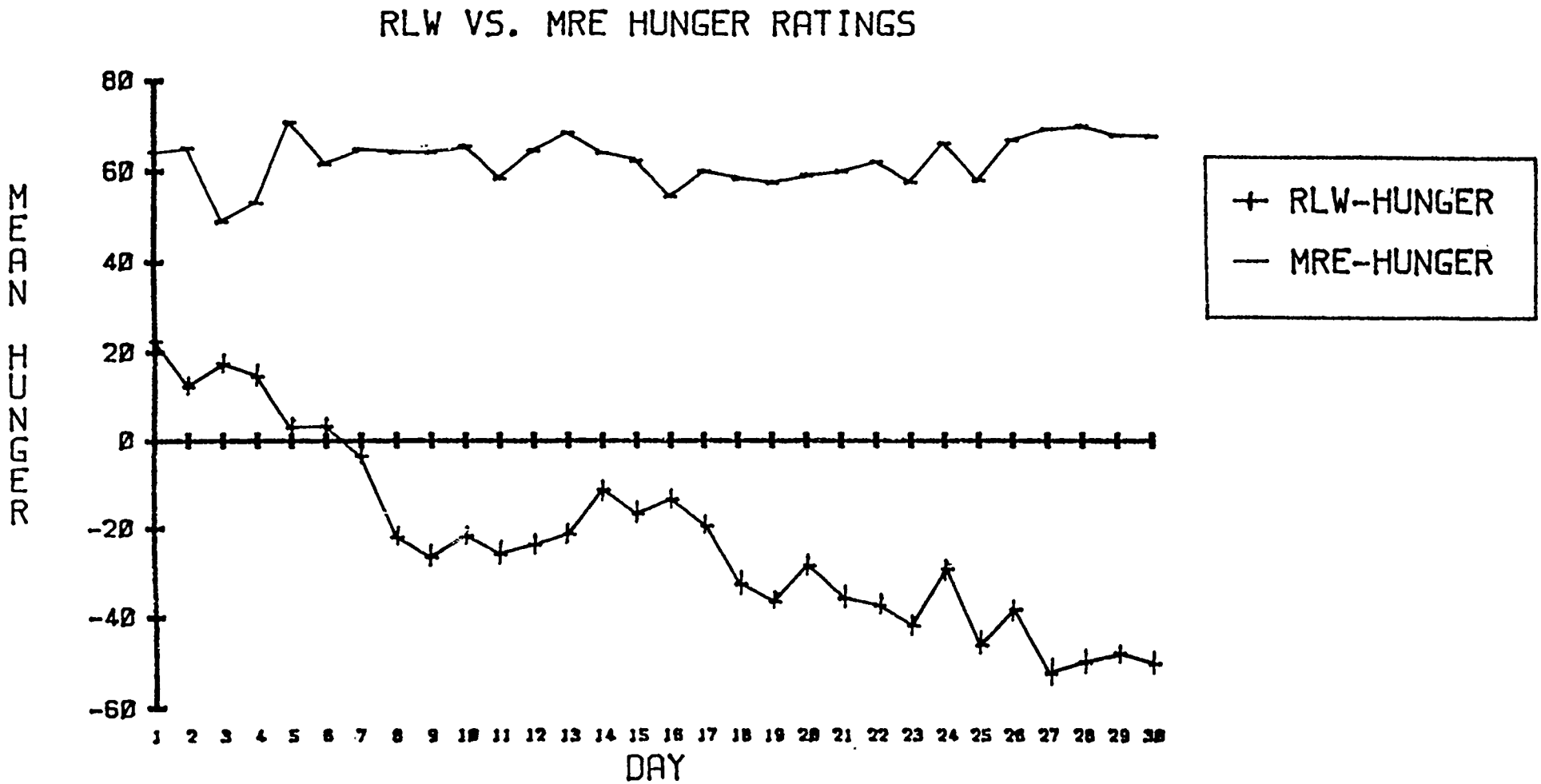

RLW VS. MRE HUNGER RATINGS
MEAN HUNGER
80
60
40
20
0
-20
-40
-60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DAY
RLW-HUNGER
MRE-HUNGER

FIGURE 3

DISCUSSION OF TEST ISSUES

DISCUSSION OF TEST ISSUES

The test issues will be discussed according to the categories of: caloric and nutritional intakes; body weight; blood constituents; symptoms and mood states; body fluid status; physical performance; mental performance; and ration acceptability and human factors.

1.1 Caloric and Nutritional Intakes

1.1.1 Will soldiers consuming the RLW-30 ration for extended periods (30 days) receive adequate amounts of nutrients to meet Military Recommended Dietary Allowances (MRDA) for operational rations as shown in Table 2-3 of AR 40-25 and/or guidance provided by the Surgeon General?

1.1.1a Mean 30 day intakes of vitamins and minerals met at least 90% of the MRDA for Vitamin D, Vitamin E, Ascorbic Acid, Thiamin, Riboflavin, Niacin, Vitamin B_6, Folacin, Vitamin B_{12}, Calcium, Phosphorous, Magnesium, Iron and Zinc. Vitamin A intakes met 78% of the MRDA. The Vitamin A intakes were not low enough to be a serious problem. Pass.

1.1.1b Sodium intakes were 2748 mg/day. This was lower than the 1700 mg of sodium/1000 kcal currently used as a guideline for operational rations. The RDA states that 1100-3300 mg/day is a safe and adequate amount. The intent of the Surgeon General in recommending 3000-3800 mg was to prevent excess sodium intakes and ease the water burden of this ration. The intakes observed were in line with this intent, however this level of sodium may be lower than advisable for non-heat acclimated soldiers functioning in a hot environment. Qualified pass.

1.1.1c Energy, carbohydrate and protein intakes were greater than 90% of the amount provided in the daily ration. The ration was routinely consumed in its entirety. Food record logs show greater than 98% of the available daily

kcal were consumed. Pass.

2.1 Body Weight

2.1.1 Will the RLW-30 maintain body weight loss within acceptable limits over a 30 day time period?

2.1.1a Mean body weight loss was less than 10% of initial body weight (6.3%). Pass.

2.1.2 Will the weight loss observed be provided predominately by the body fat component, not lean body mass or total body water?

2.1.2a The decrease in body fat accounted for only 63% of the body weight loss. The remainder, 37%, was probably from the lean body mass component, since dehydration was not evident. Fail.

2.1.3 Is the weight loss observed consistent with the caloric intake and estimated energy expenditure and hydration status?

2.1.3a The observed weight loss for the RLW-30 group was within 10% of the calculated or predicted weight loss. Estimates of caloric expenditure based upon body size and activity estimates agreed closely (within 150 kcal) of calculations of caloric expenditure based upon caloric intake and weight loss. Investigative.

2.2 Blood Constituents

2.2.1 Will the RLW-30 ration maintain blood vitamin, mineral, protein and lipid status within ranges recognized as indicative of normal nutritional status?

2.2.1a Blood chemistries for specific nutritional status indicators will be evaluated in a subsequent report. A standard panel of clinical blood chemistries revealed no clinically significant changes from pre to post 30 days in blood proteins, lipids, minerals, glucose or blood enzymes. Qualified pass.

2.2.1b Urine ketone bodies (acetoacetone) were routinely lower than 80 mg/dl and were usually in the trace to moderate

range of<10 mg/dl. Pass.

2.3 Symptoms

2.3.1 Will the RLW-30 ration support good general health as evidenced by medical evaluation (physical exam, physical symptoms)?

2.3.1a The results of the physician's physical exam were equivalent before and after the 30 day test. Pass.

2.3.1b The results of the Environmental Symptoms Questionnaire differed for the two groups. The RLW-30 group reported a significantly greater incidence and severity of hunger, increased urination, sweatiness, diarrhea, feverishness, dizziness/lightheadedness/faintness and symptoms related to visual, motor, and cognitive disturbances. Fail.

2.3.1c The incidence of gastrointestinal complaints was slightly greater for the RLW-30 group. However, the primary complaints were not severe and there was no suggestion of toxic, allergic, or malabsorptive phenomenae. One test subject reported gastrointestinal difficulties during the test and one subject reported gastrointestinal difficulties after the test was over. Their symptoms were not similar and it could not be determined if they were related to or exacerbated by diet. Qualified pass.

2.4 Body Fluid Status

2.4.1 Will soldiers fed the RLW-30 ration drink sufficient fluids to maintain hydration status?

2.4.1a Blood pressure and pulse measurements were normal and did not reveal any orthostatic changes. Group mean urine specific gravities tested<1.030 at all time periods including week 1. The absence of concentrated urines and the substantial fluid intakes reported are indicative of a normal hydration status. Pass.

2.5 Physical Performance

2.5.1 Does the RLW-30 ration support muscle strength, endurance and

aerobic capacity to at least 90% of the control (MRE) group?

2.5.1a Measurement of physical performance (handgrip strength, PT test, muscle strength, muscle endurance) were all similar to or less than 10% different from any change taking place in the MRE group. The RLW-30 group reported significantly greater perceived difficulty in strength and coordination. The decrement in $\dot{V}O_2$ max (aerobic capacity) related to body mass for the RLW-30 group was almost 22% greater than that evidenced by the MRE group (MRE,-4.5; RLW,-5.5 ml/min/kg). Pass on muscle strength and endurance, fail on aerobic capacity.

2.6 Mental Performance

2.6.1 Does the RLW-30 ration permit the maintenance of cognition and vigilance with no decrement in performance?

2.6.1a No decrements were apparent from the tests measuring vigilance and cognitive abilities. However, the RLW-30 group performed significantly less voluntary cognitive work. In addition, significant decrements were seen for the RLW-30 group in a test of psychomotor ability (simple reaction time), and perceived difficulty on a psychomotor item (type/use telegraph) was also significantly greater for the RLW-30 group. Finally, the pattern of change in perceived difficulty was significantly different for the two groups over a range of abilities. Over the course of the test, difficulty ratings increased for the RLW-30 group while they decreased for the MRE group. Qualified pass on cognition, pass on vigilance

2.6.2 Are mood and morale maintained to the same degree in the RLW-30 and the control group?

2.6.2a In comparison to the MRE group, the RLW-30 group showed few significant adverse mood changes and actually fared better than the MRE group in some respects. However, the findings are inconclusive. Pre-test data indicate the RLW-30 group had significantly less difficulty maintaining unit morale, and this difference persisted throughout the test. Qualified pass.

3.1 Ration Acceptability and Human Factors

3.1.1 Is the RLW-30 ration sufficiently palatable and acceptable to permit extended utilization (30 days) of this ration?

3.1.1a Greater than 90% of the food items in the RLW-30 were consumed. Food components were rated (hedonic scale) as good, or in some instances, better than the MRE ration. Pass.

Essential Medical/Nutritional Characteristics

How well did the RLW-30 meet the 3 essential medical/nutritional characteristics specified in the Letter Requirement (LR) for the Ration, Lightweight, 30-Day specified by TRADOC?

1.0 "The RLW-30 must meet daily minimum caloric and nutritional requirements for a 30 day ration (one food packet per day) as established by the Surgeon General (OTSG)."

The RLW-30, within the constraints placed upon it by weight and volume consideration, met the MRDA for daily minimum caloric and nutritional requirements as modified by recommendations from the Office of the Surgeon General (OTSG). The caloric intakes of 1946 kcal/day were adequate to prevent excessive (> 10%) body weight loss. The combination of low kcal and adequate but low protein intakes (protein was recommended to be low to reduce the water burden) resulted in a body weight loss that was composed of both body fat and lean body mass. The loss of lean body mass is undesirable whereas the loss of body fat (within certain limits) is not of serious consequence. The carbohydrate/caloric content of the RLW-30 should be adjusted to minimize the loss in lean body mass. It is realized that such an adjustment may conflict with logistical constraints placed upon the volume and weight of the ration.

The vitamin A intakes were less than recommended by the MRDA and could easily be increased by additional fortification.

Sodium intakes were adequate for soldiers performing moderate work in a temperate environment. Greater amounts of sodium may be needed by unacclimated soldiers using this ration in a hot environment. The level of sodium to include in operational rations is controversial, however it would seem prudent to increase the level of sodium in the RLW-30 to permit a 3000 mg of sodium/day intake to be achieved. Excess sodium would add to the water burden and should be avoided, especially with a ration such as the RLW-30 which supplies negligible food source water in its components.

2.0 "The RLW-30 must not cause unacceptable diminished soldier performance or adverse effects on health when consumed for extended periods of time."

In general, the ration did not cause serious adverse effects upon health and performance of the soldier. Decrements in physical performance were noted. It is not known if these decrements would be serious enough to compromise mission performance. These decrements in physical performance could probably be reduced by increasing the carbohydrate content of the ration. The ability of these soldiers to

perform cognitive and vigilance tasks was sustained. However, decrements in psychomotor performance, lower levels of voluntary cognitive work, and increased perceived difficulty across a range of abilities suggest potential performance problems. Mood and morale were adequately maintained, but significant pre-test differences in morale between the two groups were noted. It is noteworthy that only one RLW-30 test subject out of 18 failed to complete the 30 day test. His symptomatology appeared to be unrelated to the ration, but may have been exacerbated by the ration. The greatest weight loss experienced by a member of the RLW-30 group was 9.9% whereas the mean body weight loss was 6.3%. Physical performance is usually maintained up to weight losses of 10%. Aerobic capacity and muscle strength decreased more for the RLW-30 group than the MRE group. It is not known to what degree these decreases in physical capacity would manifest themselves in decreased mission performance. Although the modified PT test utilized in this study is not a very sensitive measure of physical performance, the RLW-30 group showed no greater decrement pre to post in this test than the MRE group.

A physical examination (evaluation of the medical status) of the RLW-30 group revealed no overt evidence of deleterious effects upon the soldier's health and physical condition.

Physical and mental impairments can be expected when this ration is utilized for extended periods of time. Within the conditions of this test, such impairments were cause for concern and caution but did not appear severe enough to seriously impair the health and performance of the soldier, provided the soldier is adequately nourished and not emaciated prior to using this ration.

3.0 "The RLW-30 ration must be sufficiently palatable to ensure consumption and of sufficient variety to achieve widest acceptability by all personnel for periods up to 30 consecutive days."

The RLW-30 ration was well received by the soldiers. In spite of the fact that there were only 6 different menus, hedonic ratings of food components (with the exception of the beverage bar) and food consumption indicated that this was a highly palatable ration. The ration was sufficiently easy to utilize from a human factors standpoint, but may require more water for utilization (for psychological satiety factors) than might be predicted from physiological considerations.

INTEGRATED DISCUSSION OF TEST RESULTS

INTEGRATED DISCUSSION OF TEST RESULTS

The metabolic effects of long term starvation and semi-starvation have been documented (1). Total fasting for a 10 day time period results in a number of medically undesirable consequences, among which are negative nitrogen balance, negative water balance, marked ketosis and a large excretion of minerals (2). Under the conditions of caloric restriction and limited water availability, a pure carbohydrate diet supplemented with a small amount of salt is relatively effective for preserving water and electrolyte homeostasis (3). Feeding 100 g of carbohydrate and a mineral supplement results in a significant improvement in the negative water, nitrogen and mineral balances (4-5). Including 40 g of protein/day along with enough carbohydrate to comprise 500 kcal/day helps further reduce the negative nitrogen balance but does not alleviate it (6). Vitamins are of lesser concern. With the exception of beriberi, classical vitamin deficiencies usually do not develop within a period of 21 days (3,7). Performance capacity is usually not adversely affected during caloric restriction that results in a gradual body weight loss (up to 10%) provided ketosis, dehydration and hyperglycemia are avoided (8). Restriction of energy intake by as little as 500 kcal/day can result in a voluntary decrease in daily activity patterns (9). Under the conditions of energy restriction, obligatory activities (those which must be performed to sustain life) have behavioral priority and are usually maintained when energy intake decreases. Discretionary activity is more likely to be reduced if energy intake is inadequate (9,10).

Although the effects of food restriction (500-2000 kcal/day) have been studied, these studies were usually for relatively short time periods of 7-14 days (11-16). There is little information available on the effects of maintaining a moderately high level of energy expenditure and operational efficiency during an extended period of moderate energy deprivation (16). Taylor et al. (8) found that limited periods of work were well

tolerated in men fed 1010 kcal/day for 24 days, although maximal oxygen uptakes declined with time. Consolazio et al. (12) reported that caloric intakes of 1,362 kcal/day were adequate to prevent loss of work performance for time periods of up to 10 days. Johnson et al. (13) found that highly motivated individuals could even perform submaximal work reasonably well on just 500 kcal/day, although some decrement in maximum performance was noted at this level of energy intake. Maximal exercise capacity can be maintained for up to 6 days during a 1000 kcal/day energy deficit (14). Crowdy et al. (15) demonstrated that men consuming 1880 kcal/day for 14 days were able to maintain an energy output of 3510 kcal/day for 14 days without appreciable deleterious effects on the performance of military tasks or physiological work capacity, compared to men consuming 3460 kcal/day. Crowdy et al. (16) subsequently studied soldiers engaged in long foot patrols in West Malaysia subsisting on 1770 or 3080 kcal/day for 12 days. He concluded that 12 days of energy restriction did not impair physical performance capacity, vigilance, arithmetic, coding or shooting skills. Consolazio et al. (11) studied several calorie dense rations under combat patrol conditions at Ft. Bragg with Special Forces soldiers and concluded that 2000 kcal/day is a good compromise for a 10 day patrol ration. Johnson (17) also recommended that a good survival-type ration should provide 2000 kcal/man/day. The literature suggests that a 2000 kcal/day ration with protein and sodium controlled to minimize osmotic load, enough carbohydrate to prevent ketosis, supplemented with vitamins and minerals will prevent dehydration, minimize nitrogen loss in the urine, support moderate work performance and result in a controlled weight loss compatible with energy reserves normally found in young well nourished male soldiers. The literature does not provide an answer to the question: Is a nutritionally complete (except for energy) 2000 kcal ration adequate to support soldier performance for 30 continuous days of Special Operations Missions?

This question can be at least partially answered by the results of this report. Medical, physiological, psychological and nutritional aspects of feeding this ration to soldiers for 30 days have been summarized and presented in the sub-sections of this report. The main findings of these sub-sections will be discussed in this section in an attempt to reach an overall medical consensus on the effectiveness of this ration in supporting the health and performance of the soldier. The ultimate decision as to the effectiveness of this ration rests with the Special Operation soldiers themselves as they utilize this ration for a variety of missions in a variety of operational environments.

Certain observations can be made regarding the medical consequences of utilizing this ration. Weight loss was moderate and within acceptable limits for this type of ration. The 6.3% weight loss was approximately twice as great as we would normally like to see (18), however it was less than weight losses normally associated with decreased physical performance (8). The weight loss observed in this study was moderate and similar to that strived for in the treatment of moderate obesity in young males (19). These soldiers, however, were not obese, but lean active athletes. In individuals such as these, any loss of lean body mass (muscular tissue) is highly undesirable. This is because maximal oxygen capacity ($\dot{V}O_2$ max) is closely associated with the active muscle mass (8). $\dot{V}O_2$ max is also influenced by cardiovascular performance which in turn is modified by training (or lack of training), myocardial disease and anemia (8). In the present study the MRE group did not lose any lean body mass but evidenced a 10.2% decrease in $\dot{V}O_2$ max over the 30 day time period. This decrease can probably be attributed to the lack of customary aerobic training due to the nature of the FTX (detraining effect). Myocardial disease and anemia can be ruled out for both groups. On the other hand, the RLW-30 group displayed a 14.8% decreased in $\dot{V}O_2$ max. That was a greater decrease than the 10.2% decrease of the

MRE group. This was a relatively small difference but was probably due to the substantial loss of lean body mass noted in the RLW-30 group. The results of muscle strength testing also reflected the effects of loss of lean body mass. The RLW-30 group was not able to maintain isokinetic strength as well as the MRE-group. No effects of ration on handgrip strength, pushups, situps, or 10 km pack test were noted in this study. These tests are less sensitive than the treadmill and cybex tests; however they do question the practical significance of the decrements observed. A decrement was seen in psychomotor ability as measured by the simple reaction time test, and the RLW-30 group performed less voluntary cognitive work. However, none of the performance tests administered showed either diminished cognitive abilities or vigilance.

There is no question that the soldiers in the RLW-30 group felt disadvantaged by the effects of the 30-day test. The weekly questionnaires revealed that the RLW-30 members perceived themselves to be more symptomatic and subject to greater performance difficulties. Symptoms consistent with decreased energy intake and increased water consumption were more intense for the RLW-30 group. In terms of performance, the RLW-30 group reported an increased sense of weakness, reduced coordination, diminished lifting capability, and greater difficulty typing/using a telegraph. In addition, the RLW-30 group showed patterns of decreasing adaptability to field conditions across a range of physical, psychomotor, cognitive, and organizational abilities while the MRE group showed increasing adaptability. In contrast, mood and morale were well-maintained relative to the MRE group. As a general assessment, the soldiers believed they were weaker as a result of subsisting entirely on the RLW-30 ration, but only two of the 16 queried felt they couldn't accomplish their mission on this ration.

The majority of the soldiers thought the ration was a good 14 day ration and that it would be adequate for a 30 day time period if foraging was permitted or if the ration could be supplemented with additional RLW-30 rations. When asked "What is the minimum number of RLW-30 rations you would require to complete a 30 day mission if you could take extra rations with you?", three out of 16 selected 30, 1 selected 40, 7 selected 45, and 5 selected 60. The after action report of the team leader of the RLW-30 group contained the following summary statement: "The use of this ration will cause a decrease in strength and endurance. Within a very specific range of applications (temperate climate, moderate work load, readily available water of 8-10 quarts/day), the RLW-30 appears to do the job. It is light and compact, and durably packed. However, it will not sustain personnel involved in heavy work-load situations (such as Escape and Evasion under pressure, very heavy rucksack loads) for longer than a week."

The results of our physiological, medical, nutritional and psychological tests support the team leader's opinion. The RLW-30 group manifested symptoms and physiological effects attributable to caloric restriction. The absolute difference in caloric intakes between the ad libitum MRE group and the calorically restricted RLW-30 group was relatively moderate (-826 kcal/man/day). This caloric deficit could be virtually eliminated by providing an additional 200 g (800 kcal) of carbohydrate/day. Providing additional carbohydrate in the diet under the conditions of reduced protein intakes and negative energy balance would also exert a beneficial effect upon nitrogen balance (5,20). While the data presented in this report do not include nitrogen balance, it is likely that negative balance did exist due to the observed loss of lean body mass. Correction of the caloric deficit (and attendant loss of lean muscular tissue) by the provision of extra carbohydrate might ameliorate the physical performance decrement and possibly a number

of physical symptoms associated with this ration. The increase in volume and weight associated with adding 200 g of carbohydrate to the ration would reduce the total number of rations that the individual soldier could carry. A separately packaged supplementary food bar containing 200 g of carbohydrate could be issued to supplement the basic ration as logistical constraints permit (ie. for missions less than 30 days where weight/volume considerations are less critical). The carbohydrate supplement bar could also be issued during high physical activity missions where physical performance is critical. The addition of carbohydrate to the ration either by changing the existing ration or by providing a separately packaged carbohydrate supplement would (1) exert a positive effect upon nitrogen balance, and (2) improve physical and possibly psychological performance.

REFERENCES

1. Keys, A., J. Brozek, A. Henschel, O. Michelsen, and H.L. Taylor. The biology of human starvation. Minneapolis, MN., Univ. of Minnesota Press, 1950.

2. Consolazio, C.F, L.O. Matoush, H.L. Johnson, R.A. Nelson and H.J. Krzywicki. Metabolic aspects of acute starvation in normal humans (10 days) Am. J. Clin. Nutr. 20: 672–683, 1967.

3. Davenport, R.E., J.K. Spaide, and R.E Hodges. An evaluation of various survival rations. Am. J. Clin. Nutr. 24: 513–523, 1971.

4. Consolazio, C.F., L.O. Matoush, H.L. Johnson, H.J. Krzywicki, G.J. Isaac and N.F. Witt. Metabolic aspects of calorie restriction: hypohydration effects on body weight and blood parameters. Am. J. Clin. Nutr. 21:793–802, 1968.

5. Consolazio, C.F., L.O. Matoush, H.L. Johnson, H.J. Krzywicki, G.J. Isaac and N.F. Witt. Metabolic aspects of calorie restriction: nitrogen and mineral balances and vitamin excretion. Am. J. Clin. Nutr. 21: 803–812, 1968.

6. Johnson, H.L., C.F. Consolazio, H.J. Krzywicki, G.J. Isaac and N.F. Witt. Metabolic aspects of calorie restriction: nutrient balances with 500-kilocalorie intakes. Am. J. Clin. Nutr. 24: 913–923, 1971.

7. Ziporin, Z.Z., W.T. Nunes, R.C. Powell, P.P. Waring and H.E. Sauberlich. Excretion of thiamin and its metabolites in the urine of young adult males receiving restricted intakes of the vitamin. J. Nutr. 85: 287–296, 1965.

8. Taylor, A.L., E.R. Buskirk, J. Brozek, J.T. Anderson, and F. Grande. Performance capacity and effects of caloric restriction with hard physical work on young men. J. Appl. Physiol. 10:421–429, 1957.

9. Gorsky, R.D. and D.H. Calloway. Activity pattern changes with decrease in food energy intake. Hum. Biol. 55: 577–586, 1983.

10. Calloway, D.H. Functional consequences of malnutrition. Rev. Infect. Dis. 4: 736–745, 1982.

11. Consolazio, C.F., L.O. Matoush, and C.W. Harris. Nutritional and acceptability evaluation of high caloric density foods under combat patrol conditions. U.S. Army Medical Research and Nutrition Laboratory, Report No. 228, 1965.

12. Consolazio, C.F., H.L. Johnson, R.A. Nelson, R. Dowdy, H.J. Krzywicki, T.A. Daws, L.K. Lowry, P.P. Waring, W.K. Calhoun, B.W. Schewenneker, and J.E. Canham. The relationship of diet to the performance of the combat soldier. Minimal calorie intake during combat patrols in a hot humid environment Presidio of San Francisco, CA. Letterman Army Institute of Research. Report No.76, 1979.

13. Johnson, H.L., L.O. Matoush C.F. Consolazio, and H.J. Krzywicki. The effects of caloric restriction upon performance. Fed. Proceedings 26:474. 1967.

14. McMurray, R.G., V. Ben-Ezra, W. Forsythe, and A.T. Smith. Responses of endurance-trained subjects to caloric deficits induced by diet or exercise. Med. Sci. Sports Exercise 17:574-579, 1985.

15. Crowdy, J.P., M.F. Haisman, and H. McGavock. Combat nutrition, The effects of a restricted diet on the performance of hard and prolonged physical work. Army Personnel Research Establishment, Farnborough, Hants. Report No. 2/71, 1971.

16. Crowdy, J.P., C.F. Consolazio, A.L. Forbes, M.F. Haisman, and D.E. Worsley. The metabolic effect of a restricted food intake on men working in a tropical environment Human Nutrition: Applied Nutrition. 36A:325-344, 1982.

17. Johnson, R.E. Caloric requirements under adverse environmental conditions. Fed. Proceedings 22:1439-1446, 1963.

18. Combat field feeding system-force development test and experimentation (CFFS-FDTE) Test Report. USACDEC, Ft. Ord, CA and USARIEM, Natick, MA. Test Report CDEC-TR-85-006A, 1986.

19. Young, C.M., S.C. Scanlan, H.S. Im, and L. Lutwak. Effect of body composition and other parameters in obese young men of carbohydrate level of reduction diet. Am. J. Clin. Nutr. 24:290-296, 1971.

20. Bortz, W.M., A. Wroldson, P. Morris and B. Issekutz, Jr. Fat, carbohydrate, salt and weight loss. Am. J. Clin. Nutr. 20:1104 -1112, 1967.

CONCLUSIONS

1. An evaluation of the ration under the conditions of this test indicates that severe medical problems should not accompany the use of this ration for light activity missions of up to 30 days duration, provided there is adequate water available and the soldiers are in good nutritional status prior to the period of ration utilization. Excessively thin (body fat below 10%) soldiers may be poor candidates to use this ration for extended periods of moderate to heavy physical activity due to low energy reserves.

2. The weight loss observed in this study (11.4 lbs/man) was not rapidly regained upon resuming "normal" food consumption, post-FTX. This indicated that the weight loss observed was true body weight loss, not dehydration.

3. Two of 18 soldiers from the RLW-30 group experienced difficulty gaining back weight due to gastrointestinal-type symptoms. The incidence of these symptoms was not believed to be related to the diet; however, the ration should be tested with a larger group of soldiers as a precautionary measure. Proteinuria and hematuria reported during daily urine dipstick testing was not severe but also merits further investigation.

4. Vigilance, morale, mood and cognitive capabilities should be maintained in well disciplined soldiers not subject to a high level of stress.

5. The ration should be tested under a variety of environmental extremes to provide Special Operational commanders and medical advisors the necessary information to plan for support of their missions.

6. The RLW-30 ration proved to be a dense, light-weight, highly palatable ration that was easy to utilize in the field and had good consumer acceptance within the constraints of caloric restriction.

7. The use of this ration for extended periods of time as the sole source of nutrition can be expected to lead to moderate weight loss accompanied by some loss of lean body mass, feelings of hunger, weakness and lightheadedness, and give rise to diminished psychomotor and physical performance capacity. Mission accomplishment can be anticipated but operational planning should allow for diminished physical capabilities and adequate recovery periods should be planned prior to beginning a new mission.

8. Performance decrements noted in this report could be reduced by increasing the carbohydrate content of this ration.

RECOMMENDATIONS

1. That the RLW ration as presently configured be utilized only for low-activity missions.
2. That a 200 g carbohydrate supplement bar be developed and issued at the rate of 1/man/day for moderate activity missions or 2/man/day for heavy activity missions.
3. That an additional operational test with a larger number of soldiers (36 soldiers for 21 days) be conducted with the RLW-30:
    a. To confirm that the GI problems noted in this test are not ration-related.
    b. To permit further medical evaluation of the transient urine hematuria and proteinuria noted in this test.
    c. To evaluate the hydration status of soldiers utilizing this ration under hot weather conditions (non-arid).
    d. To evaluate any subsequent modifications that may be made in the RLW-30 as a result of this test.

APPENDICES

APPENDIX 1

NUTRIENT COMPOSITION and MENU DESCRIPTIONS of MRE and RLW-30 RATIONS

APPENDIX 1

FIGURES

TABLES

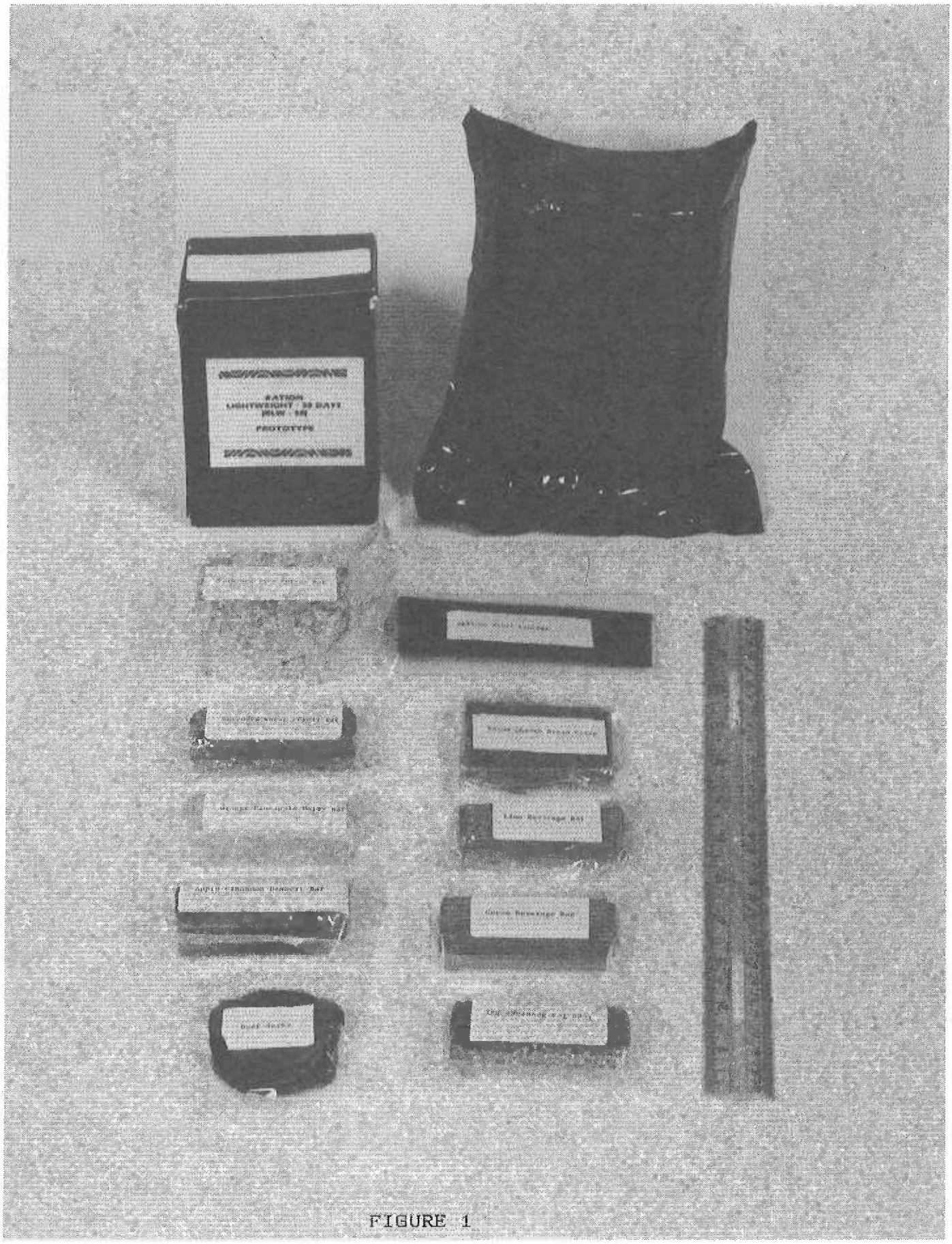


FIGURE 1

FIGURE 2

WEIGHT OF MRE VS RLW-30

ONE DAY'S RATION

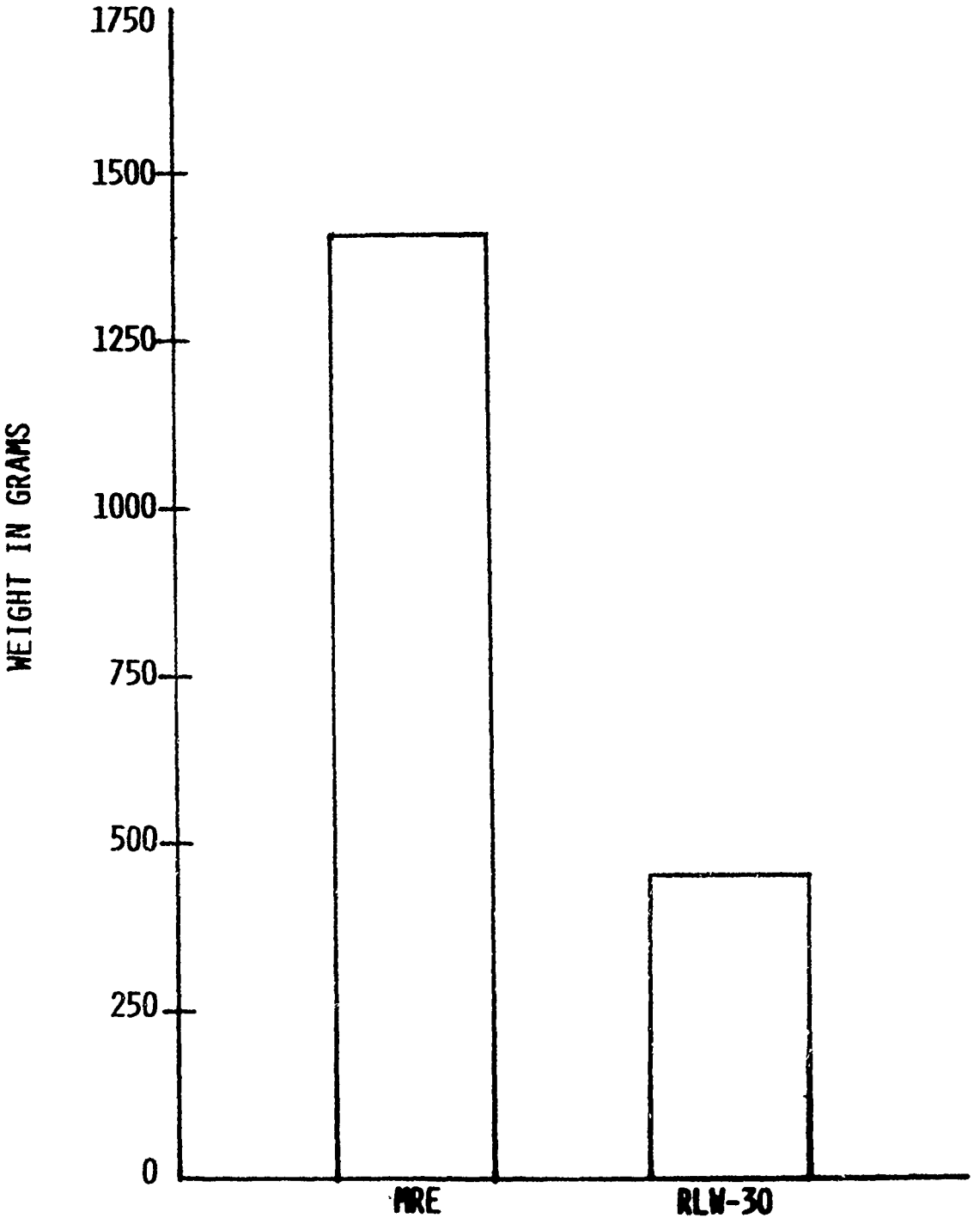


FIGURE 3

VOLUME OF MRE VS RLW-30

ONE DAY'S RATION

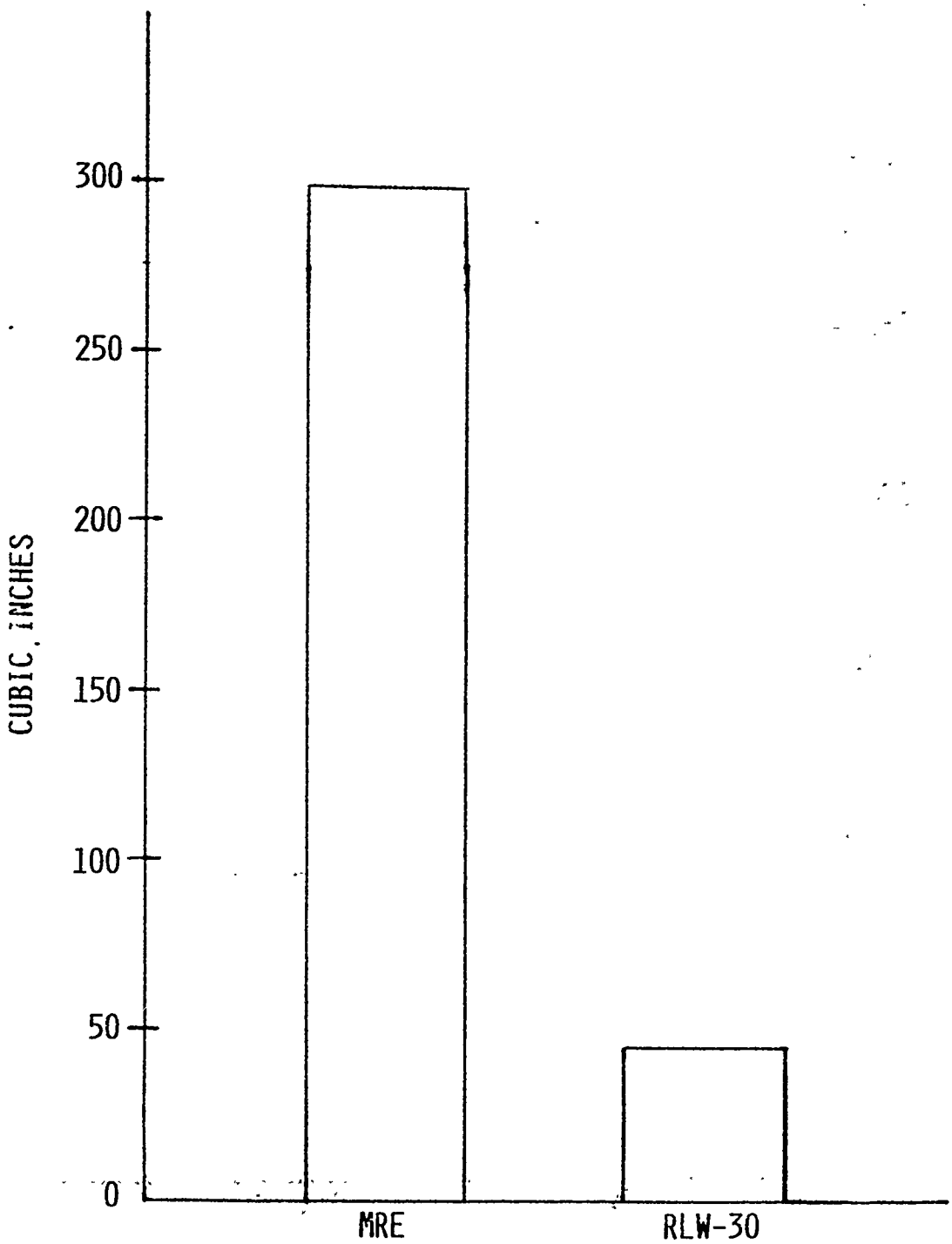


FIGURE 4

TABLE 1

RLW-30 REQUIREMENTS

WEIGHT (G)	454 OR LESS
VOLUME (CU IN.)	45 CU IN. OR LESS
PROTEIN (G)	50-60
FAT (G)	50-60 OR < 40% OF CALORIES
CHO (G)	175-200*

*ADDITIONAL IF WEIGHT AND VOLUME ALLOWS

TABLE 2

Comparison of Nutrient Composition of MRE VI and RLW-30[1]

Nutrient	MRE VI	% of Kcal	RLW-30	% of Kcal
Calories, kcal	4023		1976	
Protein, g	151	15	68	14
Fat, g	160	36	103	47
Carbohydrate, g	495	49	194	39
Water, g	498		22	
Vitamin A, mcg RE	2040		800	
Vitamin D, mcg	NA[2]		14.8	
Vitamin E, mg TE	NA[2]		124	
Ascorbic Acid, mg	317		106	
Thiamin (B_1) mg	7.1		2.2	
Riboflavin (B_2) mg	3.1		2.1	
Niacin, mg NE	38.1		27.0	
Vitamin B_6, mg	5.6		2.2	
Folacin, mcg	NA[2]		0.4	
Vitamin B_{12}, mcg	NA[2]		3.0	
Calcium, mg	1057		890	
Phosphorous, mg	2039		1248	
Magnesium, mg	404		359	
Iron, mg	25		19	
Zinc, mg	NA[2]		15.4	
Iodine, mcg	NA[2]		NA[2]	
Sodium, mg	6889		2915	
Potassium, mg	4103		1887	
Pantothenic Acid	NA[2]		5.9	
Manganese, mg	NA[2]		2.2	
Copper, mg	NA[2]		0.7	

[1] Quantities of nutrients are for one day's ration (3 MRE food packets or 1 RLW-30 food packet). The MRE VI ration was supplemented with 3 beverage powder packets containing 135 kcal and 33.8 g CHO per packet. The nutrient contribution from the beverage powder has been included in the ration totals.

[2] Nutrient values are not available.

TABLE 3

RATION LIGHTWEIGHT-30 DAYS

MENU SUMMARY

MENU	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS
MENU 1	194.6	70.2	99.6	402.5	1955.9	10.0
MENU 2	190.8	66.4	102.2	397.5	1948.5	9.0
MENU 3	195.5	67.0	105.4	406.1	1998.6	9.0
MENU 4	192.4	66.4	105.2	399.7	1979.9	9.0
MENU 5	193.8	66.4	100.7	398.0	1946.8	9.0
MENU 6	194.7	70.1	106.3	408.6	2013.7	9.0
MEAN	193.6	67.7	103.2	402.1	1973.9	9.2

MENU	%CAL FROM FAT	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
MENU 1	45.8	30.7	502.8	0.8	4.9	3.9
MENU 2	47.2	29.7	486.4	0.8	4.9	4.0
MENU 3	47.5	30.7	485.9	0.8	4.9	4.1
MENU 4	47.8	30.4	497.0	0.8	5.0	4.0
MENU 5	46.5	29.4	481.8	0.8	4.9	4.0
MENU 6	47.5	29.1	476.8	0.9	4.9	4.2
MEAN	47.1	30.0	488.4	0.8	4.9	4.0

MENU	Weight /packag	Kcal/g /package	Kcal/cc /package	Vol\package cc
MENU 1	449.2	4.4	3.6	550.2
MENU 2	435.2	4.5	3.8	513.1
MENU 3	446.4	4.5	3.7	534.9
MENU 4	448.3	4.4	3.6	551.4
MENU 5	440.3	4.4	3.6	543.4
MENU 6	450.4	4.5	3.7	537.2
MEAN	445.0	4.4	3.7	538.4

RATION LIGHTWEIGHT-30 DAYS

MENU 1

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Chicken Ala King	11.8	28.1	9.7	53.4	246.4	2.0	(2X3X3/4)2
Nacho Cheese Bread	20.2	5.4	12.7	40.9	216.9	1.0	2x3x1/2
Almond Dairy Bar	12.7	5.0	21.9	40.0	268.0	1.0	1X3X1
Blueberry Dessert B	30.2	4.2	17.3	55.0	293.3	1.0	1x3x1
Shredded Wheat Bar	38.4	5.3	12.4	60.0	286.3	1.0	2X3X5/8
Tropical Punch Bvg.	47.4	0.0	0.6	50.0	195.0	1.0	1X3X1
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	1X3X1
Fruit Leather	17.4	0.2	0.0	20.0	70.4	1.0	3/2X9/2X1/8
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	195.6	70.2	99.6	402.5	1960.0	10.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Chicken Ala King	8.5	139.0	0.4	4.6	1.8
Nacho Cheese Bread	2.6	42.9	1.0	5.3	5.1
Almond Dairy Bar	2.8	45.3	0.9	6.7	5.9
Blueberry Dessert B	3.2	52.1	1.1	5.3	5.6
Shredded Wheat Bar	3.9	63.8	0.9	4.8	4.5
Tropical Punch Bvg.	3.1	50.4	1.0	3.9	3.9
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Fruit Leather	1.4	22.9	0.9	3.5	3.1
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	30.7	502.8	0.8	4.9	3.9

*one package contains six slices

RATION LIGHTWEIGHT-30 DAYS

MENU 2

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Beef Stew	25.2	25.2	15.4	70.0	340.0	2.0	(2x3x3/4)2
Tamale Bread Crisp	19.5	5.4	12.0	39.3	207.8	1.0	(2X3X1/2)
Strawberry Dairy	15.0	4.2	20.7	40.0	262.7	1.0	(1X3X1)
Choc Chip Dessert	32.4	4.6	16.0	55.0	292.1	1.0	(1X3X1)
Wheaties Bar	37.2	5.1	12.4	60.0	280.6	1.0	(2X3X5/8)
Lemonade Bev. Bar	47.4	0.0	0.6	50.0	195.0	1.0	1X3X1
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	(1X3X1)
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	194.1	66.4	102.2	397.5	1961.8	9.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Beef Stew	8.5	139.1	0.5	4.9	2.4
Tamale Bread Crisp	2.7	43.5	0.9	5.3	4.8
Strawberry Dairy	3.0	48.7	0.8	6.6	5.4
Choc Chip Dessert	3.4	55.4	1.0	5.3	5.3
Wheaties Bar	4.0	65.2	0.9	4.7	4.3
Lemonade Bev. Bar	2.9	48.1	1.0	3.9	4.1
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	29.7	486.4	0.8	4.9	4.0

*one package contains six slices

RATION LIGHTWEIGHT-30 DAYS

MENU 3

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Pork & Rice	35.7	25.8	11.8	80.0	351.6	2.0	(2x3x3/4)2
Pizza Bread	18.7	5.2	11.7	37.9	200.8	1.0	(2X3X1/2)
Vanilla Dairy Bar	9.8	4.5	25.0	40.0	281.8	1.0	1X3X1
Apple Cinn Dessert	28.5	4.3	19.2	55.0	304.4	1.0	1x3x1
Bran Flake Bar	38.1	5.2	12.1	60.0	281.9	1.0	1x3x1
Orange Bev. Bar	47.4	0.0	0.6	50.0	195.0	1.0	(1X3X1)
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	(1X3X1)
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	195.6	67.0	105.4	406.1	1999.1	9.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Pork & Rice	8.6	140.1	0.6	4.4	2.5
Pizza Bread	2.4	40.1	0.9	5.3	5.0
Vanilla Dairy Bar	3.0	49.2	0.8	7.0	5.7
Apple Cinn Dessert	3.3	53.9	1.0	5.5	5.7
Bran Flake Bar	4.1	67.1	0.9	4.7	4.2
Orange Bev. Bar	3.0	49.1	1.0	3.9	4.0
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	29.7	485.9	0.8	4.9	4.1

*one package contains six slices

RATION LIGHTWEIGHT-30 DAYS

MENU 4

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Chicken and Rice	31.6	21.7	9.3	70.0	296.8	2.0	(2x3x3/4)2
Bacon Cheese Bread	20.3	5.7	13.0	41.5	221.0	1.0	2X3X1/2
Orange Pine. Coco.	11.5	5.4	22.0	40.0	263.0	1.0	1x3x1
Pecan Dessert Bar	25.5	4.8	22.3	55.0	321.8	1.0	1x3x1
Life Cereal Bar	35.4	6.8	12.9	60.0	285.2	1.0	2X3X5/8
Lemon Lime Bev. Bar	47.4	0.0	0.6	50.0	195.0	1.0	1x3x1
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	1x3x1
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	189.2	66.4	105.2	399.7	1966.5	9.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Chicken and Rice	8.7	143.1	0.5	4.2	2.1
Bacon Cheese Bread	2.7	43.5	1.0	5.3	5.1
Orange Pine. Coco.	3.0	48.8	0.8	6.6	5.4
Pecan Dessert Bar	3.5	57.9	0.9	5.9	5.6
Life Cereal Bar	4.1	67.4	0.9	4.8	4.2
Lemon Lime Bev. Bar	3.0	49.9	1.0	3.9	3.9
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	30.4	497.0	0.8	4.9	4.0

*one package contains six slices

RATION LIGHTWEIGHT-30 DAYS

MENU 5

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Spaghetti	30.4	27.2	7.7	71.8	299.7	2.0	(2x3x3/4)2
Coconut Bread	20.4	3.2	13.1	38.0	212.1	1.0	2X3X1/2
Mixed Nut Dairy Br	11.3	5.0	25.0	40.0	290.2	1.0	1x3x1
Choc Halva Dessert	30.4	4.5	17.6	55.0	297.8	1.0	1x3x1
Grapenut Cereal Br	38.9	4.6	11.6	60.0	278.5	1.0	2X3X5/8
Strawberry Bev. Bar	47.4	0.0	0.6	50.0	195.0	1.0	1x3x1
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	1x3x1
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	196.3	66.4	100.7	398.0	1956.9	9.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Spaghetti	8.5	139.1	0.5	4.2	2.2
Coconut Bread	2.9	46.8	0.8	5.6	4.5
Mixed Nut Dairy Br	2.9	48.1	0.8	7.3	6.0
Choc Halva Dessert	3.1	50.2	1.1	5.4	5.9
Grapenut Cereal Br	3.8	61.5	1.0	4.6	4.5
Strawberry Bev. Bar	3.0	49.7	1.0	3.9	3.9
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	29.4	481.8	0.8	4.9	4.1

*one package contains six slices

RATION LIGHTWEIGHT-30 DAYS

MENU 6

FOOD ITEM	CHO (g)	PRO (g)	FAT (g)	WT. (g)	KCAL	NO.OF ITEMS	CONFIGURATI (in)
Chili	27.5	31.2	15.9	81.2	378.3	2.0	(2x3x3/4)2
Orange Nut Bread	21.4	4.2	12.1	39.2	211.2	1.0	2X3X1/2
Banana Dairy	12.3	4.7	22.8	40.0	266.8	1.0	1x3x1
Graham Dessert	30.3	3.5	17.8	55.0	295.7	1.0	1x3x1
Corn Flake Bar	39.4	4.5	11.9	60.0	283.0	1.0	2X3X5/8
Raspberry Bev. Bar	47.4	0.0	0.6	50.0	195.0	1.0	1x3x1
Cocoa Bev Bar	15.1	3.3	20.0	40.0	253.1	1.0	1x3x1
Beef Jerky*	2.5	18.7	5.1	43.2	130.5	1.0	1.7X.9
	195.7	70.1	106.3	408.6	2013.7	9.0	

*one package contains six slices

FOOD ITEM	VOL (in3)	VOL (cc)	DEN (g/cc)	Kcal /g	Kcal /cc
Chili	8.1	132.8	0.6	4.7	2.8
Orange Nut Bread	2.6	42.3	0.9	5.4	5.0
Banana Dairy	2.8	46.1	0.9	6.7	5.8
Graham Dessert	3.2	51.9	1.1	5.4	5.7
Corn Flake Bar	4.0	64.8	0.9	4.7	4.4
Raspberry Bev. Bar	3.2	52.5	1.0	3.9	3.7
Cocoa Bev Bar	2.6	43.2	0.9	6.3	5.9
Beef Jerky*	2.6	43.2	1.0	3.0	3.0
	29.1	476.8	0.9	4.9	4.2

*one package contains six slices

TABLE 4

DESCRIPTION OF MRE MENUS

	MRE I-V	MRE VI
Menu 1	Pork Ssg Patty (d) Applesauce Cheese Spread Crackers Cookies, Choc. Cocoa Bev Prod Catsup (1154 Kcal)	Pork Ssg Patty (d) Applesauce Cheese Spread Crackers Cookies, Choc. Cocoa Bev Prod Catsup (1154 Kcal)
Menu 2	Ham/Chick Loaf Strawberry (d) Peanut Butter Crackers Pineapple Nut Cake (1151 Kcal)	Ham/Chick Loaf Strawberry (d) Peanut Butter Crackers Beans/Tom. Sauce Candy (1154 Kcal)
Menu 3	Beef Patty (d) Beans/Tom.Sauce Cheese spread Crackers Brownie, choc Soup/Gravy base Candy (1293 Kcal)	Beef Patty (d) Beans/Tom. Sauce Cheese spread Crackers Brownie, choc Soup/gravy base Candy (1293 Kcal)
Menu 4	Beef/BBQ Peaches (d) Peanut Butter Crackers Cookies, choc. Candy (1229 Kcal)	Beef/BBQ - 8 oz Peaches (d) Peanut butter Crackers Cookies, choc. (1178 Kcal)
Menu 5	Beef Stew Fruit mix (d) Peanut butter Crackers Cherry Nutcake Cocoa Bev. Prod (1330 K cal)	Beef Stew - 8 oz Fruit mix (d) Cheese spread Crackers Cherry Nut Cake (1148 Kcal)
Menu 6	Frankfurt Bean/Tom sauce Jelly Crackers Cocoa Bev. prod Candy Catsup (1216 Kcal)	Frankfurt Bean/Tom. sauce Jelly Crackers Cocoa bev prod Candy Catsup (1216 Kcal)
Menu 7	Turk/Gravy Potato Patty (d) Jelly Crackers Maple Nut Cake Cocoa Bev. prod (1267 Kcal)	Turk/Gravy - 8 oz Strawberries (d) Jelly Crackers Maple Nut Cake Cocoa Bev Prod (1272 Kcal)
Menu 8	Beef/Gravy Beans/Tom sauce Cheese spread Crackers Brownie, choc (1055 Kcal)	Beef/Gravy - 8 oz Peaches (d) Jelly Crackers Brownie, choc Cocoa Bev prod (1133 Kcal)
Menu 9	Chick Ala King Cheese spread Crackers Fruitcake Cocoa Bev prod (1145 Kcal)	Chic Ala King -8 oz Cheese spread Crackers Fruitcake Cocoa Bev prod (1248 Kcal)
Menu 10	Meatball/BBQ Potato Patty (d) Jelly Crackers Choc Nut Cake Cocoa Bev prod (1352 Kcal)	Meatball/BBQ -8 oz Strawberries (d) Peanut Butter Crackers Cookies, choc (1222 Kcal)
Menu 11	Ham Slices Peaches (d) Cheese spread Crackers Orange Nut roll Cocoa Bev base (1234 Kcal)	Ham Slices Peaches (d) Cheese spread Crackers Orange nut roll Cocoa Bev base (1234 Kcal)

COMPARISON OF MRE MENUS (Cont)

	MRE I-V	MRE VI
Menu 12	Beef w/spice sauce	Beef w/spice sauce
	Strawberries (d)	Strawberries (d)
	Peanut butter	Peanut butter
	Crackers	Crackers
	Cookies, choc	Cookies, choc
	Candy	
	(1245 Kcal)	(1198 Kcal)

Note: Each menu also contains coffee (Vit. C fortified), Cream Substitute sugar, salt

MRE VI was supplemented with 1 beverage/menu which contains 135 kcal,33.8g CHO and 24 mg Vit C/ packet. Three beverage powder packets were supplied / man / day. MRE I-V were not used in this study,but are included for comparative purposes.

APPENDIX 2
DAILY ENVIRONMENTAL CONDITIONS and OPERATIONAL ACTIVITY SUMMARIES

DAILY ENVIRONMENTAL CONDITIONS

Date	Day	Temperature (°F) High	Low	Weather Conditions
Sept. 24	1	Barracks, Lock Down Area, Ft. Devens		
25	2	" " " " " "		
26	3	45	30	?
27	4	51	35	?
28	5	59	50	?
29	6	61	55	Rainy, overcast
30	7	56	50	" "
Oct. 1	8	61	50	Damp, partly cloudy
29	55	45		?
3	10	53	45	Overcast, high winds, rain/sleet
4	11	52	48	Rain
5	12	50	40	Foggy to partly cloudy
6	13	40	35	Cold, snow
7	14	45	35	Cold, sunny
8	15	50	45	Mild, sunny
9	16	47	39	Overcast, drizzle
10	17	38	25	Sunny
11	18	40	25	"
12	19	45	25	Overcast
13	20	50	40	?
14	21	50	40	Overcast
15	22	50	40	Morning foggy, afternoon sunny
16	23	53	42	?
17	24	55	39	Overcast
18	25	60	35	Clear, sunny
19	26	55	40	?
20	27	55	40	?
21	28			
	Lab	Barracks, Lock Down Area Ft. Devens and USARIEM		
22	29	" " " " " " " "		
23	30	" " " " " " " "		

DAILY OPERATIONAL ACTIVITY SUMMARY

Date		Day	MRE Group	RLW-30 Group
Sept.	24	1	Mission Planning	Mission Planning
	25	2	" "	" "
	26	3	Initial infil. 1.5 km move, 100 lb rucks, equip checks	Initial infil., 1-2 km move, 100 lb rucks
	27	4	2.2 km move, 100 lb rucks, set up MSS	4-5 km move, 100 lb rucks
	28	5	4 km recon move, 25 lb day packs	Local recon, 2-3 km, no packs
	29	6	Water runs only, no recon.	Local recon, 2-3 km, no packs
	30	7	4 km move to exfil point, 95 lb rucks	2 km movement, 95 lb rucks
Oct.	1	8	Static, medical test, resupply	Static, Medical tests
	2	9	Infil, 2 km move, 100 lb rucks, set up base camp	Infil, 2 km move, 90 lb rucks
	3	10	Static	Static, local recon
	4	11	Remained at base camp, water runs only	Static, local recon
	5	12	Local recon, no packs	Static, local recon
	6	13	Remained at base camp in Static, positions	local reconsheltered
	7	14	Exfil, 2 km movement, 95 lb rucks	Exfil, 2 km move, 85 lb rucks
	8	15	Static, medical tests, resupply	Static, medical test
	9	16	Infil, 3 km move, 100 lb rucks	Infil, 5 km move up mountain, 75 lb rucks
	10	17	Recon, 8 km move, 25 lb day packs	Mountain recon, 5-8km, no pack
	11	18	Recon, 10 km move, 25 lb day packs	Mountain recon, 5-8km, no pack
	12	19	Equipment maintenance, water runs only	8 km move, 70 lb rucks
	13	20	Static	Static
	14	21	Exfil, 4 km move, 95 lb rucks	Exfil, 4 km move, 70 lb rucks
	15	22	Static, medical test, resupply	Static, medical test
	16	23	Infil, 1.5 km move, 100 lb rucks, set up base camp	Infil, 4 km move, 65 lb rucks
	17	24	Local recon, 6 km move, 25 lb day packs	Static, local recon
	18	25	Static	Static, local recon
	19	26	Exfil, 4 km move, 85 lb rucks	Static, local recon
	20	27	Movement by truck and bus to Ft. Devens	Exfil 4 km move, 60 lb rucks, move by bus & truck to Ft. Devens

21	28	Post	FTX	Testing,	Evaluation	and	Debriefing				
22	29	"	"	"	"	"	"				
23	30	"	"	"	"	"	"				

APPENDIX 3
DAILY FOOD AND WATER CONSUMPTION LOG BOOK

RLW-30

FOOD LOG BOOK

LIGHT WEIGHT RATION

Name_____

Test Subject Number_____

This is your log book to record the quantity of food and water you eat each day for one week. These books will be collected and new log books issued at the end of the week. While the recording of this data daily may seem tedious and repetitious to you, it is very important that you be as thorough and complete as possible, because this data will be used to calculate whether or not you received adequate nutrition (recommended dietary allowances) each day. You must fill these pages out daily. A quick entry after each meal will help you avoid forgetting to mark down food items or fluids consumed.

Remember: -Mark down all snacks
-you may save food items to be eaten later, but you can not trade food items.

We are also interested in improving the quality of this ration. Your ratings and comments will help us make better rations for you. Thank you for your cooperation.

DAY

LIGHT WEIGHT RATION CONSUMPTION

Please circle the number that indicates how much of each item that you ate today. If the appropriate number is not listed, write it on the line provided. For ex: If you eat 2 beef stew entrees, circle 2. If you eat 1/2 of the beef jerky, circle 1/2. If you use 1 1/2 packages of cocoa, write in "1 1/2"

ADDED WATER
Please list the amount of water you added to each food or beverage item consumed. Write in "0" if you did not add water to an item that you consumed.

RATING OF FOOD
Please circle the numbers that indicate how much you liked or disliked the ration items that you ate today.

REASONS FOR NOT FINISHING
On the line provided, please write in a reason why you did not finish any ration item that you ate today.

Rating scale: 1 Dislike Extremely, 2 Dislike Very Much, 3 Dislike Moderately, 4 Dislike Slightly, 5 Neither Like/Dislike, 6 Like Slightly, 7 Like Moderately, 8 Like Very Much, 9 Like Extremely

FOOD ITEM	CODE	AMOUNT CONSUMED (by package)	WATER (in cant. cups) (i.e.: 1/4, 1/2,3/4,1,etc.)	RATING	REASONS
CEREAL BARS					
Bran Flake Cereal	57	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Corn Flake Cereal	58	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Grapenut Cereal	62	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Life Cereal	61	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Shredded Wheat Cereal	60	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Wheaties Cereal	59	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
ENTREES					
Beef Stew	54	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Chicken ala King	50	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Chicken and Rice	56	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Chili	53	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Pork and Rice	51	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Spaghetti	55	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Beef Jerky	52	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
BREAD BARS					
Bacon Cheese	66	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Coconut	67	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Nacho Cheese	65	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Orange Nut	64	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Pizza	63	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____
Tamale	68	1/4 1/2 3/4 1 2 ____	____	1 2 3 4 5 6 7 8 9	____

DAY

DAIRY BARS	CODE	AMOUNT CONSUMED					WATER (in cant. cups) (i.e.: 1/4, 1/2,3/4,1,etc)	RATING OF FOOD (1 Dislike Extremely, 2 Dislike Very Much, 3 Dislike Moderately, 4 Dislike Slightly, 5 Neither Like/Dislike, 6 Like Slightly, 7 Like Moderately, 8 Like Very Much, 9 Like Extremely)	REASON FOR NOT FINISHING
Almond	49	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Banana	45	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Mixed Nut	44	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Orange Pineapple Coconut	47	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Strawberry	46	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Vanilla	48	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
DESSERTS									
Apple Cinnamon	69	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Blueberry	74	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Chocolate Chip	70	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Chocolate Halva	71	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Fruit Leather	75	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Graham	73	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Pecan	72	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
DRINKS									
Cocoa	39	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Coffee Cube	86	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Lemonade Beverage	43	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Orange Beverage	41	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Raspberry Beverage	84	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Strawberry Beverage	40	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Tropical Punch Beverage	42	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Lemon-Lime Beverage	83	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
Tea	85	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____
OTHER									
Tabasco	87	1/4	1/2	3/4	1	2 ____	_____	1 2 3 4 5 6 7 8 9	_____

PLEASE COMPLETE AFTER EATING DINNER

If +100 is the fullest you can imagine, and -100 is the hungriest, how full or hungry are you now?_____

DAY

WATER CONSUMPTION

Circle the total amount of unflavored water that you drink or use during each time period listed below. Do not record flavored water such as coffee, cocoa, kool-aid, tea on this page; record these items on ration consumption page. If you drink or use more than two canteens during one time period, write the total amount on the line provided.

CIRCLE YOUR CANTEEN SIZE: 1 qt 2 qt

	DRINKING (Not water used to prepare food or beverages.)	OTHER (Ex: washing, shaving, heating entrees. NOT plain water drank or used to rehydrate food or beverage items.)
During Breakfast	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Breakfast and Lunch	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
During Lunch	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Lunch and Dinner	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
During Dinner	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Dinner and Breakfast	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Daily Total	_____ Canteens	_____ Canteens

MRE

FOOD LOG BOOK

MRE

Name_____

Test Subject Number_____

This is your log book to record the quantity of food and water you eat each day for one week. These books will be collected and new log books issued at the end of the week. While the recording of this data daily may seem tedious and repetitious to you, it is very important that you be as thorough and complete as possible, because this data will be used to calculate whether or not you received adequate nutrition (recommended dietary allowances) each day. You must fill these pages out daily. A quick entry after each meal will help you avoid forgetting to mark down food items or fluids consumed.

Remember: -Mark down all snacks
-you may save food items to be eaten later, but you can not trade food items.

We are also interested in improving the quality of this ration. Your ratings and comments will help us make better rations for you. Thank you for your cooperation.

DAY

MRE RATION CONSUMPTION

Please circle the number that indicates how much of each item that you ate today. If the appropriate number is not listed, write it on the line provided. For ex: If you eat 2 beef stew entrees, circle 2. If you eat only 1 cracker, circle 1/2. If you drink 2 1/2 canteen cups of coffee, write in "2 1/2".

ADDED WATER

Please list the amount of water you added to each food or beverage item consumed. Write in "0" if you did not add water to an item that you consumed.

RATING OF FOOD

Please circle the numbers that indicate how much you liked or disliked the ration items that you ate today.

REASONS FOR NOT FINISHING

On the line provided, please write in a reason why you did not finish any ration item that you ate today.

FOOD ITEM	CODE	AMOUNT CONSUMED (by package)	WATER (in canteen cups) (i.e.: 1/4, 1/2,3/4,1,etc)	RATING (1 Dislike Extremely, 2 Dislike Very Much, 3 Dislike Moderately, 4 Dislike Slightly, 5 Neither Like/Dislike, 6 Like Slightly, 7 Like Moderately, 8 Like Very Much, 9 Like Extremely)	REASONS FOR NOT FINISHING
ENTREES					
Beef w/barbeque sauce	14	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Beef w/gravy	12	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Beef w/spiced sauce	10	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Beef patties	6	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Beef stew	7	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Chicken ala king	76	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Frankfurters	13	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Ham/chicken loaf	5	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Ham slices	9	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Meatballs w/barbeque sauce	11	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Pork sausage patties	4	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Turkey w/gravy	8	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
STARCH					
Crackers	17	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Beans w/tomato sauce	15	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Potato patty	78	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
SPREAD					
Cheese	3	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Jelly	31	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________
Peanut butter	16	1/4 1/2 3/4 1 2 ____	________	1 2 3 4 5 6 7 8 9	________

DAY

ENTREE	CODE	AMOUNT CONSUMED (by package)						WATER(in cant. cups (i.e. 1/4, 1/2,3/4,1,etc.)	RATING	REASON FOR NOT FINISHING
FRUIT										
Applesauce	24	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Mixed fruits	25	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Peaches	26	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Strawberries	27	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
DESSERT										
Brownie	22	1/4	1/2	3/4	1	2	____	_____		
Cherry nut cake	18	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Chocolate covered cookie	23	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Fruitcake	20	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Maple nut cake	19	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Orange nut cake	21	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Pineapple nut cake	80	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Chocolate nut cake	81	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
									1 2 3 4 5 6 7 8 9	_____
BEVERAGE										
Beverage Powder	77	1/4	1/2	3/4	1	2	____	_____		
Cocoa Powder	29	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Coffee	37	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Cream substitute	2	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Sugar	38	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
									1 2 3 4 5 6 7 8 9	_____
OTHER										
Catsup	28	1/4	1/2	3/4	1	2	____	_____		
Gravy base (soup mix)	1	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Candy (all types)	—	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Gum	82	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
Salt	79	1/4	1/2	3/4	1	2	____	_____	1 2 3 4 5 6 7 8 9	_____
									1 2 3 4 5 6 7 8 9	_____

1 Dislike Extremely
2 Dislike Very Much
3 Dislike Moderately
4 Dislike Slightly
5 Neither Like/Dislike
6 Like Slightly
7 Like Moderately
8 Like Very Much
9 Like Extremely

REASON FOR NOT FINISHING
On the line provided, please write in a reason why you did not finish any ration item that you ate today.

PLEASE COMPLETE AFTER EATING DINNER:
If +100 is the fullest you can imagine, and -100 is the hungriest, how full or hungry are you now? _____

DAY

WATER CONSUMPTION

Circle the total amount of unflavored water that you drink or use during each time period listed below. Do not record flavored water such as coffee, cocoa, kool-aid, tea on this page; record these items on ration consumption page. If you drink or use more than two canteens during one time period, write the total amount on the line provided.

CIRCLE YOUR CANTEEN SIZE: 1 qt 2 qt

	DRINKING (Not water used to prepare food or beverages.)	OTHER (Ex: washing, shaving, heating entrees. NOT plain water drank or used to rehydrate food or beverage items.)
During Breakfast	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Breakfast and Lunch	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
During Lunch	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Lunch and Dinner	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
During Dinner	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Between Dinner and Breakfast	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens	1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 ___ Canteens
Daily Total	_____ Canteens	_____ Canteens

COMMENTS

Please make any comments about this ration, how you feel as a result of eating it, how you would improve it, etc.

APPENDIX 4
DAILY URINE CHEMISTRY LOG SHEET

MEDICAL LOG SHEET

Using the multistix provided, please test your urine daily for its specific gravity (a hydration measure) and for the presence of ketone bodies (by-products of fat metabolism.)

Simply dip one multistix into your urine collection container immediately after your first urination upon waking. Make sure that all of the colored pads on the multistix have been covered with urine.

Remove the multistix, wait approximately 15 seconds and compare the color of the ketone pad (5th pad which was orginally peach colored) with the color scale for reading your ketone value shown on the multistix bottle cover. Record the value (negative, 5, 15, 40, 80, or 160) on the space provided below for the appropriate day.

After a total of 45-60 seconds, compare the color of the specific gravity pad (9th or last pad which was originally mustard yellow colored) with the color scale for reading your specific gravity value shown on the multistix bottle cover. Record the value (1.000, 1.005, 1.010, 1.015, 1.020, 1.025, 1.030) on the space provided below for the appropriate day.

If you feel ill, nauseous, or have G.I. disturbances (cramps, diarrhea, constipation), list your symptoms after the urine charts. Record if you had a bowel movement today.

CHECK APPROPRIATE COLUMN

KETONES

Day	NEGATIVE	TRACE 5	SMALL 15	MODERATE 40	80	LARGE 160
1						
2						
3						
4						
5						
6						
7						

SPECIFIC GRAVITIES

Day	1.000	1.005	1.010	1.015	1.020	1.025	1.030
1							
2							
3							
4							
5							
6							
7							

BOWEL MOVEMENTS

	YES	NO
1		
2		
3		
4		
5		
6		
7		

SYMPTOMS (i.e. Fever,Cold,Cramps,Diarrhea,etc)

APPENDIX 5
CALCULATION OF ENERGY REQUIREMENTS AND PREDICTED 30 DAY BODY WEIGHT LOSS

PREFACE

The calculations in this section are based upon the following references:

Durnin, J.V.G.A. and R. Passmore. Energy, Work, and Leisure. Heineman Educational Books, London, England. 1967.

Wilmore, D.W. The Metabolic Management of The Critically Ill. Plenum, N.Y., N.Y., 1977.

Pellet, P.L. Food Energy Requirements in Man. Submitted for publication, Am. J. Clin. Nutr. 1986.

I. Assumptions regarding activity levels were made by integrating activity logs and conversations with the Special Forces Soldiers taking part in this FTX. These relative activity levels are likely to vary greatly depending upon the mission and are presented here as estimates only.

II. The following calculations are presented:

1. Calculation of energy expenditure based upon activity estimates.

2. Calculation of energy requirements of the MRE group based upon energy intake and body weight loss.

3. Calculation of energy requirements of the RLW-30 group based upon energy intake and body weight loss.

4. Calculation of predicted 30 day body weight loss of RLW-30 group.

Calculation of Energy Expenditure Based Upon Activity Estimates

- Known values:

1) Mean age = 27 years
2) Mean height = 70 inches
3) Mean weight (RLW-30 group) = 179 lbs

- Derived values from known values:

1) Resting energy expenditure (REE) = 1750 kcal/day

- Multiples of resting energy expenditure (activity factors):

1) Sleeping, resting, reclining = 1.0
2) Very light = 1.5
3) Light = 2.5
4) Moderate = 5.0
5) Heavy = 7.0

- Assumed values:

1) Surveillance days = 10 hr resting; 10 hr very light; 4 hr light activities
2) Patrol - reconnaissance days = 10 hr resting; 8 hr very light; 6 hr moderate activities
3) Infiltration-exfiltration days = 10 hr resting; 8 hr very light; 6 hr heavy activities
4) During typical 30 day missions 50% of the days will be surveillance missions, 25% of the days will be patrol-reconnaissance missions and 25% of the days will be infiltration-exfiltration missions

- Calculations:

Surveillance days activity	hrs	Multiples of REE (activity factor)		Mean activity factor
Resting	10	x 1.0	=	10
Very light	10	x 1.5	=	15
Light	4	x 2.5	=	10
				35 ÷ 24 = 1.46

Patrol-Reconnaissance days activity

Resting	10	x	1.0	=	10
Very light	8	x	1.5	=	12
Moderate	6	x	5.0	=	30
					52 ÷ 24 = 2.17

Infiltration-exfiltration days activity

Resting	10	x	1.0	=	10
Very light	8	x	1.5	=	12
Heavy	6	x	7.0	=	42
					64 ÷ 24 = 2.67

-Daily estimates of energy expenditure:

Surveillance days
1750 kcal REE x 1.46 activity factor = 2555 kcal/day

Patrol-reconnaissance days
1750 kcal REE x 2.17 activity factor = 3798 kcal/day

Infiltration-exfiltration days
1750 kcal REE x 2.67 activity factor = 4673 kcal/day

- Mean 30 day estimate of energy expenditure:

% of days		daily energy requirement, kcal		fractional contribution, kcal
50	x	2555	=	1276
25	x	3798	=	950
25	x	4673	=	1168
				3394 kcal/day

Calculation of Energy Requirement of the MRE - Group Based Upon Energy Intake and Body Weight Loss

What is the energy expenditure of a 27 year old male Special Forces Soldier initially weighing 169 lbs, 70" tall who lost 4.0 lbs over a 30 day period while consuming 2782 kcal/day?

Assumption: That the caloric equivalency of the body weight loss was 3500 kcal/lb.

1. Energetic equivalency of the body weight loss over 30 days:

   4.0 lbs x 3500 kcal/lb = 14,000 kcal/30 days

2. Energy intake:

   2782 kcal/day x 30 days = 83,460 kcal/30 days

3. Energy requirement to achieve 0 body weight loss:

   14,000 kcal loss + 83,460 kcal consumed = 97,460 kcal

4. Daily energy requirement:

   97,460 kcal ÷ 30 days = 3249 kcal/day

Calculation of Energy Requirement of the RLW-30 Group Based upon Energy Intake and Body Weight Loss

What is the energy expenditure of a 27 year old male Special Forces Soldier initially weighing 179 lbs, 70" tall who lost 11.4 lbs over a 30 day time period while consuming 1946 kcal/day?

Assumption: That the caloric equivalency of the body weight loss was 3500 kcal/lb.

1. Energetic equivalency of the body weight loss over 30 days:

   11.4 lbs x 3500 kcal/lb = 39,900 kcal/30 days

2. Energy intake:

   1946 kcal/day x 30 days = 58,380 kcal/30 days

3. Energy requirement to achieve 0 body weight loss:

   39,900 kcal loss + 58,380 kcal consumed = 98,280 kcal

4. Daily energy requirement:

98,280 kcal / 30 days = 3276 kcal/day

Calculation of Predicted 30 Day Body Weight Loss of RLW-30 Group

How much body weight loss should a 27 year old male Special Forces Soldier weighing 179 lbs, 70" tall consuming 1946 kcal/day sustain over a 30 day period?

1. Body surface area = 2.0 m^2
2. Resting energy expenditure = 1750 kcal/day
3. Activity factor = 1.94 (weighted average of 1.46, 2.17, 2.67 activity factors)
4. Total 30 day caloric expenditure:

   30 days x 1750 kcal/day x 1.94 = 101,850 kcal
5. Caloric intake for the 30 day period:

   30 days x 1946 kcal/day = 58,380 kcal
6. Caloric balance

   Caloric balance = Calorie in - Calories out

   = 58,380 - 101,850

   = -43,470 kcal
7. Weight loss equivalancy of energy deficit:

   (Assuming 1 lb weight loss is equivalent to 3500 kcal)

   -43,470 kcal ÷ 3500 kcal/lb body weight = -12.4 lbs/30 days

APPENDIX 6
INDIVIDUAL SYMPTOMS SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR All SUBJECTS

INDIVIDUAL SYMPTOMS SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR ALL SUBJECTS (N=36). ASTERISKS INDICATE SIGNIFICANT POST HOC DIFFERENCES.

	MEAN INTENSITY					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
tiredness	0.31	1.08**	0.67	1.03**	1.06**	+248	+116	+232	+242
backache	0.25	1.33**	0.89*	0.86**	0.86*	+432	+256	+244	+244
leg ache	0.22	0.78*	0.61	0.89*	0.69	+255	+177	+305	+214
chilliness	0.14	0.53	1.36**	1.25**	0.69*	+279	+871	+793	+393
cold hands	0.25	0.31	1.42**	1.44**	0.69	+24	+468	+476	+176
cold feet	0.22	0.44	1.67**	1.36**	0.67	+100	+659	+518	+205
restlessness	0.19	0.53	0.47	0.67*	0.92**	+179	+147	+253	+384
boredom	1.33	1.86	1.94	2.14*	2.28*	+40	+46	+61	+71
gas	0.14	0.11	0.25	0.64*	0.78*	−21	+79	+357	+457
numbness	0.00	0.03	0.36	0.47*	0.22	–	–	–	–
thirst	0.28	0.44	0.50	0.61	0.86**	+57	+79	+118	+207
decreased urination	0.00	0.36	0.14	0.36	0.50*	–	–	–	–
shivering	0.08	0.11	0.56	0.56	0.56	+38	+600	+600	+600
depression	0.17	0.17	0.28	0.47	0.58	0	+64	+176	+241

APPENDIX 7
INDIVIDUAL MOOD STATES SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR All SUBJECTS

INDIVIDUAL MOOD STATES SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR ALL SUBJECTS (N=35). ASTERISKS INDICATE SIGNIFICANT POST HOC DIFFERENCES.

	MEAN INTENSITY					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
full of pep	2.66	2.00**	1.71**	1.71**	1.57**	−25	−36	−36	−41
vigorous	2.27	1.60*	1.54*	1.37**	1.31**	−26	−29	−37	−40
energetic	2.69	2.23*	2.17*	2.14*	1.74**	−17	−19	−20	−35
goodnatured	3.06	2.69	2.25**	2.40**	1.94**	−12	−26	−21	−37
lively	2.54	2.29	1.94**	2.06*	1.80**	−10	−24	−19	−29
helpful	2.60	2.43	2.06*	1.97*	1.66**	−7	−21	−24	−36
trusting	2.69	2.40	2.14	1.71**	1.60**	−11	−20	−36	−41
sympathetic	1.74	1.57	1.46	1.17*	0.71**	−10	−16	−33	−59
deceived	0.20	0.14	0.46	0.71*	0.66*	−30	+130	+255	+230
resentful	0.11	0.11	0.17	0.54*	0.60*	0	+55	+391	+445
alert	2.80	2.77	2.40	2.37	1.97**	−1	−14	−15	−30
efficient	2.71	2.69	2.20	2.29	1.69**	−24	−41	−6	+92
relaxed	2.69	2.37	2.54	2.20	1.60**	−12	−6	−18	−41
furious	0.26	0.03	0.14	0.57	0.77*	−88	−46	+119	+196
unhappy	0.40	0.77	0.60	0.69	0.83*	+93	+50	+73	+108
exhausted	0.54	0.89	0.54	0.97	0.97	+65	0	+80	+80
worn out	0.86	1.34	0.91	1.17	1.37	+56	+6	+36	+59
bitter	0.20	0.06	0.20	0.29	0.54	−70	0	+45	+170
annoyed	0.83	0.66	0.49	0.91	1.09	−20	−41	+10	+31
on edge	0.66	0.57	0.46	0.46	0.83	−14	−30	−30	+25
considerate	2.71	2.69	2.31	2.09	2.06	−1	−15	−23	−24
rebellious	1.43	0.63	0.77	1.11	1.14	−56	−46	−22	−20

APPENDIX 8
INDIVIDUAL PERFORMANCE DIFFICULTY RATINGS SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR All SUBJECTS

INDIVIDUAL PERFORMANCE DIFFICULTY RATINGS SHOWING SIGNIFICANT ANOVA DIFFERENCES OVER TEST WEEKS FOR ALL SUBJECTS (N=36). ASTERISKS INDICATE SIGNIFICANT POST HOC DIFFERENCES.

	MEAN INTENSITY					% CHANGE			
	PRE	1	2	3	4	1	2	3	4
push/pull a heavy object	-	1.56	0.92**	1.06**	1.06**	-	-41	-32	-32
follow orders	-	0.25	0.47	0.97**	0.92**	-	+88	+288	+268
cooperate with civilians	-	0.14	0.19	0.72**	0.67**	-	+36	+414	+379
take charge of emergencies	-	0.06	0.25	0.42**	0.36*	-	+317	+600	+500
risk own safety for others	-	0.19	0.28	0.69**	0.58*	-	+47	+263	+205
respond quickly	-	0.16	0.36	0.56**	0.42	-	+125	+250	+163
be professional with civilians	-	0.19	0.28	0.75**	0.58	-	+47	+295	+205
support policies of superiors	-	0.72	0.78	1.52**	1.19	-	+8	+111	+65
follow the chain of command	-	0.53	0.56	1.19*	0.81	-	+6	+125	+53
observe regs on	-	0.33	0.36	0.75*	0.44	-	+9	+127	+33
show respect for superiors	-	0.75	0.83	1.33*	1.08	-	+11	+77	+44
improve own performance	-	0.22	0.25	0.53*	0.47	-	+14	+14	+114
present a good image of the Army	-	0.53	0.64	1.03*	0.83	-	+21	+94	+57
identify problems	-	0.22	0.17	0.42	0.42	-	-23	+91	+91
help others improve their performance	-	0.39	0.22	0.64	0.44	-	-44	+64	+13
coordinate both arms/legs	-	0.31	0.36	0.64	0.61	-	+16	+106	+97
maintain balance	-	0.81	0.61	1.08	0.75	-	-25	+33	-7

APPENDIX 9
30 DAY STUDY, VERMONT RLW-30, QUESTIONNAIRE RESULTS

TABLE-1 Time in the Special Forces/Months

Mean ----- 42.88
SD ----- 48.38

TABLE-2 Special Forces Rank Percentage

Corporal	11.8
Buck Sergeant	41.2
Staff Sergeant	17.6
Sergeant First Class	17.6
Chief Warrent Officer-2	5.9
First Lieutenant	5.9

TABLE-3 Age/Years

Mean ----- 27.65
SD ----- 4.51

TABLE-4 Please use the following scale to indicate how much you liked or disliked each of the items in the ration you ate by circling the number that best expresses your opinion.

DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE
1	2	3	4	5

LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
6	7	8	9

		MEAN	SD
ENTREE BARS:	Beef Stew	6.06	1.89
	Chicken ala King	6.35	1.93
	Chicken and Rice	7.47	1.01
	Chili	7.29	1.61
	Pork and Rice	6.59	1.84
	Spaghetti	7.29	1.83
	Beef Jerky	7.88	1.17
BREAD BARS:	Bacon Cheese	6.18	2.01
	Coconut	6.76	2.36
	Nacho Cheese	6.06	1.92
	Orange Nut	6.12	1.87
	Pizza	6.88	1.73
	Tamale	6.71	1.86
CEREAL BARS:	Bran Flake	7.88	1.11
	Corn Flake	7.76	1.30
	Grapenut	7.94	1.14
	Life	8.00	1.06
	Shredded Wheat	7.94	1.09
	Wheaties	7.94	1.14

		MEAN	SD
DESSERTS:	Apple Cinnamon	8.24	0.90
	Blueberry	7.41	1.46
	Chocolate Chip	7.88	1.17
	Chocolate Halva	8.06	1.20
	Fruit Leather	7.59	1.66
	Graham	8.18	1.13
	Pecan	8.06	1.14
DAIRY BARS:	Almond	7.76	1.25
	Banana	7.76	1.20
	Mixed Nut	7.71	1.45
	Orange-Pineapple-Coconut	7.71	1.26
	Strawberry	7.71	1.53
	Vanilla	7.06	1.78
DRINKS:	Cocoa	7.41	1.62
	Coffee Cube	7.07	2.13
	Lemonade Bev.	4.82	2.43
	Orange Bev.	5.00	2.42
	Raspberry Bev.	5.18	2.88
	Strawberry Bev.	5.12	2.91
	Tropical Punch	5.12	2.69
	Lemon-Lime Bev.	4.29	2.49
	Tea	7.53	1.59
OTHER:	Tabasco	8.33	1.23

TABLE-5 How do you feel that this ration affected your overall performance?

Extremely Positive Effect	Moderately Positive Effect	Slightly Positive Effect	No Effect Either Way
1	2	3	4

Slightly Negative Effect	Moderately Negative Effect	Extremely Negative Effect
5	6	7

Mean ----- 5.24
SD ----- 1.44

TABLE-6 If you had only this ration to eat, in combat, how many more days would it have sustained you?

# DAYS	PERCENTAGE
0	29.4
4	5.9
7	5.9
10	11.8
14	11.8
15	5.9
30	5.9
45	5.9
NO REPLY	17.6

MEAN ----- 10.64
SD ----- 13.07

TABLE-7 If changes were to be made to the rations that you ate during this test, what characteristic of the ration would you most want to see changed? Please rank the following changes by placing a "1" next to the most important change a "2" next to the second most important, etc.

CHANGES	PERCENTAGE OF IMPORTANCE 1st	2nd	3rd	4th	5th	6th	7th
Be lighter	5.9	17.6	--	11.8	--	11.8	--
Take up less space	--	11.8	11.8	5.9	17.6	--	5.9
Easier to open	--	11.8	--	5.9	5.9	11.8	5.9
Less thirst	5.9	11.8	11.8	5.9	11.8	--	11.8
Taste better	--	11.8	--	5.9	5.9	--	--
More variety	5.9	23.5	5.9	--	--	11.8	5.9
More filling	70.6	11.8	--	--	--	--	--
Not crumble	--	11.8	--	--	5.9	5.9	5.9
Less rehydrating	--	17.6	17.6	5.9	--	--	--
Rehydrate faster	11.8	11.8	--	5.9	--	5.9	11.8
Other	5.9	--	5.9	--	5.9	--	--

	PERCENTAGE OF IMPORTANCE (cont) 8th	9th	10th	11th	UNRANKED MEAN	SD
Be lighter	5.9	--	5.9	5.9	35.1	5.09	3.42
Take up less space	--	5.9	5.9	--	35.1	5.00	2.68
Easier to open	--	11.8	5.9	--	41.2	6.00	2.83
Less thirst	--	--	--	--	41.2	3.90	2.08
Taste better	17.6	5.9	5.9	--	47.1	6.22	3.03
More variety	5.9	5.9	--	--	35.1	4.36	2.87
More filling	--	--	--	--	17.6	1.14	0.36
Not crumble	17.6	5.9	5.9	--	41.2	6.50	2.76
Less rehydrating	--	5.9	5.9	--	47.1	4.22	3.07
Rehydrate faster	5.9	--	5.9	--	41.2	4.80	3.22
Other	--	--	--	11.8	70.6	6.20	4.60

TABLE-8 If you could design your own daily ration using the same packages of bars as you had available and the same total number (i.e., 8), how many of each type of package would you want per day?

TYPE OF BAR	MEAN	SD
Entree	1.25	0.68
Crispy Bread	0.63	0.50
Dairy	1.56	0.63
Fruit Beverage	0.00	0.00
Cocoa Beverage	0.81	0.66
Dessert	1.00	0.63
Cereal	1.44	0.89
Fruit Pockets	0.44	0.51
Beef Jerky	0.94	0.77

TABLE-9 We would like to know how satisfied you were with the variety in each part of the ration. Was there enough variety or should there be more? Please circle one number for each component of the ration.

ENOUGH VARIETY	SHOULD HAVE SOMEWHAT MORE VARIETY	SHOULD HAVE MODERATELY MORE VARIETY	SHOULD HAVE MUCH MORE VARIETY
1	2	3	4

TYPE OF BAR	MEAN	SD
Entree	2.13	1.36
Crispy Bread	2.19	1.22
Dairy	2.07	1.22
Fruit Beverage	1.62	1.12
Dessert	1.81	0.98
Cereal	1.50	0.82
Fruit	1.93	1.10
Cocoa Beverage	1.60	0.99

TABLE-10 How often did you have enough water available to rehydrate (mix with water) the food items that you wanted to rehydrate?

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER
1	2	3	4	5	6	7

Mean ----- 1.53
SD ----- 0.94

TABLE-11 How often was the amount of water you brought into the field enough to satisfy your thirst?

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER
1	2	3	4	5	6	7

Mean ----- 2.53
SD ----- 1.91

TABLE-12 Were you resupplied with water during the exercise?

Yes ----- 17.6%
No ----- 82.4%

TABLE-13 Did you obtain additional pick-up water?

Yes ----- 93.8%
No ----- 6.3%

TABLE-14 If you did obtain pick-up water, did you use iodine tablets to disinfect the water?

Yes ----- 50.0%
No ----- 50.0%

TABLE-15 How long did you wait (in minutes) after adding the tablets before you used the water for eating/drinking?

Mean ----- 31.67
SD ----- 16.77

TABLE-16 On the Average, how many quarts of water did you use each day for drinking and eating?

Mean ----- 4.82
SD ----- 2.97

TABLE -17 How often did you rehydrate (mix with water) the dehydrated (dry) components of your ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

TYPE OF BAR	MEAN	SD
Entree	4.94	0.24
Dairy	3.47	1.62
Fruit Beverage	3.38	1.54
Cereal	3.41	1.66
Cocoa	3.76	1.64

TABLE-18 What were your reasons for NOT REHYDRATING (mixing with water) the dehydrated (dry) components of your ration? Circle ALL reasons that apply to you. If you always added water to your dry components, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Dehydrated foods tasted better dry	17.6	82.4
Dehydrated foods had better texture dry	11.8	88.2
Not enough water available for mixing	0.0	100.0
Too much trouble to mix with water	29.4	70.6
Not enough time to mix with water	11.8	88.2
Other reasons	29.4	70.6
Always added water to dry rations	23.4	76.5

TABLE-19 Did you use iodinated water for rehydration of the dehydrated components of the ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

MEAN ----- 2.35
SD ----- 1.37

TABLE-20 How often did you use HOT water to mix with the dehydrated (dry) entree bars of your ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

MEAN ----- 4.71
SD ----- 0.99

TABLE-21 What were your reasons for NOT using HOT water to rehydrate your entree bars? Circle ALL reasons that apply to you. If you ALWAYS used hot water, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Entree bars tasted better with cold water	0.0	100.0
Entree bars had better texture with cold water	0.0	100.0
Not enough water available for rehydrating	0.0	100.0
No equipment available for heating	0.0	100.0
Too much trouble to heat water	0.0	100.0
Not enough time to heat water	0.0	100.0
Other reasons	5.9	94.1
Always heated my entree bars	88.2	11.8

TABLE-22 Overall, did you get enough to eat or were you hungry?

1 - Got enough to eat
2 - Was sometimes hungry
3 - Was often hungry
4 - Was almost always hungry

Mean ----- 3.29
SD ----- 0.77

TABLE-23 If you DID NOT eat enough, why? Circle ALL the reasons that apply to you. If you DID Eat enough, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Disliked the rations	0.0	100.0
Not enough rations	82.4	17.6
Not enough time to eat	5.9	94.1
Too tired to eat	0.0	100.0
Other	0.0	100.0
Always ate enough during this exercise	11.8	88.2

TABLE-24 Overall, how CONVENIENT (easy) was the ration to use in the field?

EXTREMELY CONVENIENT	MODERATELY CONVENIENT	NEUTRAL	MODERATELY INCONVENIENT	EXTREMELY INCONVENIENT
1	2	3	4	5

Mean ----- 2.25
SD ----- 1.18

TABLE-25 Does this ration require more or less water than: MRE

MORE	SAME	LESS
1	2	3

Mean ----- 1.13
SD ----- 0.34

TABLE-26 Does this ration require more or less water than: LRP

MORE	SAME	LESS
1	2	3

Mean ----- 1.93
SD ----- 0.73

TABLE-27 Please rate the ration that you ate during this test on each of the following factors.

EXCELLENT	GOOD	FAIR	POOR
1	2	3	4

FACTOR	MEAN	SD
Light weight	1.41	0.71
Takes up little space	1.65	0.70
Tastes good	1.53	0.80
Stops my hunger	3.71	0.59
Gives me enough energy to do my job	3.29	0.85

TABLE-28 For each of the items in the accessory packet, please indicate whether you needed more of the item, less of the item, or had just the right amount.

ITEM	NEED MORE	% NEED LESS	% JUST THE RIGHT AMOUNT
Toilet Paper	18.8	50.0	31.3
Spoons	12.5	18.8	68.8
Matches	31.3	12.5	56.3
Tabasco sauce	70.6	0.0	29.4
Iced tea	50.0	6.3	43.8
Coffee cubes	75.0	6.3	18.8
Gum	25.0	12.5	62.5
Twist ties	0.0	86.7	13.3

TABLE-29 Use the following scale to indicate how much you feel that eating your daily ration serves as a source of diversion/entertainment to break up the day, or as a way to kill time when not performing mission duties.

UNNECESSARY DIVERSION	USEFUL DIVERSION	NECESSARY DIVERSION
1	2	3

Mean ----- 2.47
SD ----- 0.72

TABLE-30 What are the MOST IMPORTANT factors in a combat ration for a mission such as the one you were on? Please rank the factors below by placing a "1" next to the most important factor, and a "2" next to the second most important factor, and so on for the third, fourth, and fifth factors.

	PERCENTAGE OF IMPORTANCE					RANK		
FACTOR	1ST	2ND	3RD	4TH	5TH	UNRANKED	MEAN	SD
Light weight	52.9	17.6	23.5	0.0	5.9	0.0	1.88	1.17
Takes up little space	11.8	41.2	23.5	23.5	0.0	0.0	2.59	1.00
Tastes good	0.0	17.6	11.8	17.6	47.1	5.9	4.00	1.21
Stops my hunger	29.4	5.9	11.8	35.3	11.8	5.9	2.94	1.53
Gives me enough energy to do my job	47.1	17.6	17.6	5.9	5.9	5.9	2.00	1.26

TABLE-31 Where you resupplied with water during the exercise?

Yes ----- 40.0%
No ----- 60.0%

TABLE-32 Even though it would be heavier and take up more space, the ration should have more calories.

DISAGREE STRONGLY	DISAGREE SLIGHTLY	NEUTRAL	AGREE SLIGHTLY	AGREE STRONGLY
1	2	3	4	5

Mean ----- 4.12
SD ----- 1.36

APPENDIX 10
30 DAY STUDY, VERMONT MRE QUESTIONNAIRE RESULTS

TABLE-1 Time in the Special Forces/Months

Mean ----- 37.94
SD ----- 43.88

TABLE-2 Special Forces Rank Percentage

Private First Class	5.6
Corporal	27.8
Buck Sergeant	22.2
Staff Sergeant	22.2
Sergeant First Class	16.7
Chief Warrent Officer 2	5.6

TABLE-3 Age/Years

Mean ----- 25.94
SD ----- 4.88

TABLE-4 Please use the following scale to indicate how much you liked or disliked each of the items in the ration you ate by circling the number that best expresses your opinion.

DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE
1	2	3	4	5

LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
6	7	8	9

		MEAN	SD
ENTREE BARS:	Beef with Barbecue Sauce	6.24	1.92
	Beef with Gravy	6.00	2.13
	Beef with Spiced Sauce	6.94	1.60
	Beef Patties	6.83	1.47
	Beef Stew	7.29	1.57
	Chicken ala King	6.35	2.26
	Frankfurters	6.50	2.41
	Ham/Chicken Loaf	2.44	2.03
	Ham Slices	5.39	2.23
	Meatballs w/Barbecue Sauce	6.47	1.55
	Pork Sausage	6.65	1.58
	Turkey w/Gravy	6.61	1.94
STARCH:	Crackers	7.28	1.56
	Beans w/Tomato Sauce	7.12	1.65
	Potato Patty	7.00	1.54
SPREAD:	Cheese	5.94	2.80
	Jelly	7.06	2.08
	Peanut Butter	7.39	1.97

		MEAN	SD
FRUIT:	Applesauce	8.50	0.99
	Mixed Fruits	7.28	1.41
	Peaches	7.39	1.54
	Strawberries	8.06	1.39
	Pears	7.33	1.66
DESSERT:	Cherry Nut Cake	5.38	2.19
	Chocolate Covered Cookie	7.28	2.37
	Fruitcake	3.94	2.59
	Maple Nut Cake	5.67	2.63
	Orange Nut Cake	3.25	2.02
	Pineapple Nut Cake	4.13	2.28
	Chocolate Nut Cake	6.61	2.68
BEVERAGE:	Beverage Powder	7.89	1.32
	Cocoa Powder	8.29	1.05
	Coffee	6.82	2.21
	Cream Substitute	7.41	1.73
	Sugar	7.53	1.96
OTHER:	Catsup	6.73	1.56
	Gravy Base (soup)	7.73	1.39
	Candy (all types)	6.39	2.00
	Gum	6.89	1.71
	Salt	5.18	0.87

TABLE-5 How do you feel that this ration affected your overall performance?

Extremely Positive Effect	Moderately Positive Effect	Slightly Positive Effect	No Effect Either Way
1	2	3	4

Slightly Negative Effect	Moderately Negative Effect	Extremely Negative Effect
5	6	7

Mean ----- 4.55
SD ----- 0.98

TABLE-6 If you had only this ration to eat, in combat, how many more days would it have sustained you?

# DAYS	PERCENTAGE
0	11.1
8	5.6
15	11.1
30	22.2
45	5.6
INDEFINITELY	33.3
NO REPLY	11.1

TABLE-7 If changes were to be made to the rations that you ate during this test, what characteristic of the ration would you most want to see changed? Please rank the following changes by placing a "1" next to the most important change a "2" next to the second most important, etc.

PERCENTAGE OF IMPORTANCE

CHANGES	1st	2nd	3rd	4th	5th	6th	7th
Be lighter	27.8	44.4	5.6	5.6	--	11.1	--
Take up less space	55.6	11.1	16.7	--	11.1	--	--
Easier to open	--	22.2	11.1	5.6	11.1	11.1	--
Less thirst	5.6	16.7	--	5.6	16.7	11.1	11.1
Taste better	16.7	22.2	11.1	11.1	5.6	11.1	5.6
More variety	5.6	16.7	11.1	5.6	5.6	--	16.7
More filling	22.2	16.7	5.6	22.2	5.6	5.6	--
Not crumble	--	22.2	--	--	--	--	11.1
Less rehydrating	5.6	11.1	5.6	--	--	16.7	11.1
Rehydrate faster	11.1	5.6	--	5.6	11.1	--	--
Other	11.1	--	--	5.6	--	--	--

PERCENTAGE OF IMPORTANCE (cont.)

	8th	9th	10th	11th	UNRANKED	MEAN	SD
Be lighter	--	--	--	--	5.6	2.35	1.58
Take up less space	--	--	--	--	5.6	1.94	1.39
Easier to open	5.6	5.6	11.1	5.6	11.1	5.50	3.20
Less thirst	11.1	5.6	5.6	--	11.1	5.44	2.71
Taste better	--	5.6	--	--	11.1	3.63	2.39
More variety	11.1	--	--	--	27.8	4.54	2.57
More filling	5.6	5.6	--	--	11.1	3.56	2.48
Not crumble	11.1	22.2	11.1	--	22.2	6.71	3.22
Less rehydrating	--	5.6	11.1	5.6	27.8	6.15	3.34
Rehydrate faster	5.6	11.1	11.1	16.7	22.2	6.79	3.70
Other	--	--	--	--	83.3	2.00	1.73

TABLE-8 We would like to know how satisfied you were with the variety in each part of the ration. Was there enough variety or should there be more? Please circle one number for each component of the ration.

ENOUGH VARIETY	SHOULD HAVE SOMEWHAT MORE VARIETY	SHOULD HAVE MODERATELY MORE VARIETY	SHOULD HAVE MUCH MORE VARIETY
1	2	3	4

TYPE OF BAR	MEAN	SD
Entrees	2.94	0.87
Starch	2.94	1.16
Spread	2.67	1.14
Fruit	2.39	1.20
Dessert	2.56	1.34
Beverage	2.50	1.34

TABLE- 9 How often did you have enough water available to rehydrate (mix with water) the food items that you wanted to rehydrate?

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER
1	2	3	4	5	6	7

Mean ----- 1.83
SD ----- 0.99

TABLE-10 How often was the amount of water you brought into the field enough to satisfy your thirst?

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER
1	2	3	4	5	6	7

Mean ----- 3.78
SD ----- 2.07

TABLE-11 Were you resupplied with water during the exercise?

Yes ----- 68.8%
No ----- 31.3%

TABLE-12 Did you obtain additional pick-up water?

Yes ----- 100.0%
No ----- 0.0%

TABLE-13 If you did obtain pick-up water, did you use iodine tablets to disinfect the water?

Yes ----- 64.7%
No ----- 35.3%

TABLE-14 How long did you wait (in minutes) after adding the tablets before you used the water for eating/drinking?

Mean ----- 28.46
SD ----- 8.99

TABLE-15 On the Average, how many quarts of water did you use each day for drinking and eating?

Mean ----- 2.72
SD ----- 0.86

TABLE -16 How often did you rehydrate (mix with water) the dehydrated (dry) components of your ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

TYPE OF BAR	MEAN	SD
Entree	3.11	1.71
Starch	2.88	1.65
Fruit	3.47	1.84
Beverage	4.65	1.00

TABLE-17 What were your reasons for NOT REHYDRATING (mixing with water) the dehydrated (dry) components of your ration? Circle ALL reasons that apply to you. If you always added water to your dry components, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Dehydrated foods tasted better dry	0.0	100.0
Dehydrated foods had better texture dry	5.6	94.4
Not enough water available for mixing	5.6	94.4
Too much trouble to mix with water	5.6	94.4
Not enough time to mix with water	5.6	94.4
Other reasons	11.1	88.9
Always added water to dry rations	44.4	55.6

TABLE-18 Did you use iodinated water for rehydration of the dehydrated components of the ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

MEAN ----- 2.76
SD ----- 1.64

TABLE-19 How often did you use HOT water to mix with the dehydrated (dry) entree bars of your ration?

NEVER	LESS THAN HALF THE TIME	ABOUT HALF THE TIME	MORE THAN HALF THE TIME	ALWAYS
1	2	3	4	5

MEAN ------ 3.61
SD ----- 1.54

TABLE-20 What were your reasons for NOT using HOT water to rehydrate your entree bars? Circle ALL reasons that apply to you. If you ALWAYS used hot water, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Entree bars tasted better with cold water	0.0	100.0
Entree bars had better texture with cold water	0.0	100.0
Not enough water available for rehydrating	0.0	100.0
No equipment available for heating	11.1	88.9
Too much trouble to heat water	16.7	83.3
Not enough time to heat water	16.7	83.3
Other reasons	5.6	94.4
Always heated my entree bars	66.7	33.3

TABLE-21 Overall, did you get enough to eat or were you hungry?

1 - Got enough to eat
2 - Was sometimes hungry
3 - Was often hungry
4 - Was almost always hungry

Mean ----- 1.78
SD ----- 0.81

TABLE-22 If you DID NOT eat enough, why? Circle ALL the reasons that apply to you. If you DID Eat enough, circle that one only.

REASON	% CIRCLED	% NOT CIRCLED
Disliked the rations	38.9	61.1
Not enough rations	33.3	66.7
Not enough time to eat	5.6	94.4
Too tired to eat	0.0	100.0
Other	11.1	88.9
Always ate enough during this exercise	38.9	61.1

TABLE-23 Overall, how CONVENIENT (easy) was the ration to use in the field?

EXTREMELY CONVENIENT	MODERATELY CONVENIENT	NEUTRAL	MODERATELY INCONVENIENT	EXTREMELY INCONVENIENT
1	2	3	4	5

Mean ----- 2.72
SD ----- 0.89

TABLE-24 Please rate the ration that you ate during this test on each of the following factors.

EXCELLENT	GOOD	FAIR	POOR
1	2	3	4

FACTOR	MEAN	SD
Light weight	3.39	0.50
Takes up little space	3.67	0.49
Tastes good	2.94	0.80
Stops my hunger	2.67	0.77
Gives me enough energy to do my job	2.61	0.85

TABLE-25 Use the following scale to indicate how much you feel that eating your daily ration serves as a source of diversion/entertainment to break up the day, or as a way to kill time when not performing mission duties.

UNNECESSARY DIVERSION	USEFUL DIVERSION	NECESSARY DIVERSION
1	2	3

Mean ----- 2.06
SD ----- 0.64

TABLE-26 Where you resupplied with water during the exercise?

Yes ----- 61.1%
No ----- 38.9%

TABLE-27 What are the MOST IMPORTANT factors in a combat ration for a mission such as the one you were on? Please rank the factors below by placing a "1" next to the most important factor, and a "2" next to the second most important factor, and so on for the third, fourth, and fifth factors.

	PERCENTAGE OF IMPORTANCE					RANK		
FACTOR	1ST	2ND	3RD	4TH	5TH	UNRANKED MEAN	SD	
Light weight	50.0	11.1	11.1	11.1	11.1	5.6	2.18	1.51
Takes up little space	27.8	22.2	16.7	16.7	11.1	5.6	2.59	1.42
Tastes good	11.1	27.8	5.6	5.6	38.9	11.1	3.38	1.63
Stops my hunger	22.2	16.7	16.7	22.2	11.1	11.1	2.81	1.42
Gives me enough energy to do my job	38.9	11.1	22.2	16.7	--	11.1	2.19	1.22

APPENDIX 11
RLW-30 DAY STUDY, RLW ACCEPTANCE DATA

RLW DATA
OCTOBER, 1986

** WEEK 1 **
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
44	MIXED-NUT DAIRY BAR	7.39	0.47
45	BANANA DAIRY BAR	7.55	0.58
46	STRAWBERRY DAIRY BAR	7.00	0.53
47	ORANGE-PINEAPPLE-COCONUT BAR	7.33	0.33
48	VANILLA DAIRY BAR	7.21	0.68
49	ALMOND DAIRY BAR	7.48	0.29
50	CHICKEN ALA KING ENTREE BAR	7.20	0.43
51	PORK AND RICE ENTREE BAR	7.69	0.40
52	BEEF JERKY	7.80	0.15
53	CHILI ENTREE BAR	6.70	0.79
54	BEEF STEW ENTREE BAR	7.60	0.32
55	SPAGHETTI ENTREE BAR	7.15	0.52
56	CHICKEN AND RICE BAR	7.29	0.32
57	BRAN FLAKE CEREAL BAR	7.67	0.24
58	CORN FLAKE CEREAL BAR	6.75	0.37
59	WHEATIES CEREAL BAR	7.43	0.37
60	SHREDDED WHEAT BAR	7.36	0.29
61	LIFE CEREAL BAR	7.90	0.28
62	GRAPENUT CEREAL BAR	7.50	0.33
63	PIZZA BREAD BAR	6.21	0.55
64	ORANGE-NUT BREAD BAR	5.91	0.69
65	NACHO CHEESE BREAD BAR	5.88	0.44
66	BACON CHEESE BREAD BAR	7.30	0.34
67	COCONUT BREAD BAR	7.53	0.40
68	TAMALE BREAD BAR	6.60	0.60
69	APPLE CINNEMON DESSERT BAR	7.75	0.35
70	CHOCOLATE CHIP DESSERT BAR	7.57	0.29
71	CHOCOLATE HALVA DESSERT BAR	8.38	0.18
72	PECAN DESSERT BAR	8.00	0.53
73	GRAHAM DESSERT BAR	7.55	0.34
74	BLUEBERRY DESSERT BAR	7.69	0.27
75	FRUIT LEATHER	8.17	0.34
83	LEMON-LIME BEVERAGE BAR	7.25	0.53
39	COCOA BAR	7.57	0.14
40	STRAWBERRY BEVERAGE BAR	5.89	0.84
41	ORANGE BEVERAGE BAR	7.33	0.55
42	TROPICAL FRUIT BEVERAGE BAR	5.27	0.69
43	LEMONADE BEVERAGE BAR	6.27	0.54
84	RASPBERRY BEVERAGE BAR	6.82	0.52
85	TEA	7.92	0.19
86	COFFEE CUBE	7.60	0.26
87	TABASCO	8.39	0.16

R L W D A T A
OCTOBER, 1986

** WEEK 2 **
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
44	MIXED-NUT DAIRY BAR	7.89	0.23
45	BANANA DAIRY BAR	7.70	0.25
46	STRAWBERRY DAIRY BAR	7.81	0.26
47	ORANGE-PINEAPPLE-COCONUT BAR	7.42	0.27
48	VANILLA DAIRY BAR	7.44	0.33
49	ALMOND DAIRY BAR	7.93	0.28
50	CHICKEN ALA KING ENTREE BAR	7.58	0.40
51	PORK AND RICE ENTREE BAR	7.50	0.31
52	BEEF JERKY	8.16	0.10
53	CHILI ENTREE BAR	7.90	0.28
54	BEEF STEW ENTREE BAR	7.57	0.27
55	SPAGHETTI ENTREE BAR	7.75	0.25
56	CHICKEN AND RICE BAR	8.00	0.19
57	BRAN FLAKE CEREAL BAR	8.06	0.22
58	CORN FLAKE CEREAL BAR	7.46	0.22
59	WHEATIES CEREAL BAR	8.14	0.29
60	SHREDDED WHEAT BAR	7.76	0.23
61	LIFE CEREAL BAR	7.55	0.30
62	GRAPENUT CEREAL BAR	8.10	0.21
63	PIZZA BREAD BAR	6.93	0.46
64	ORANGE-NUT BREAD BAR	6.46	0.39
65	NACHO CHEESE BREAD BAR	6.39	0.58
66	BACON CHEESE BREAD BAR	6.52	0.41
67	COCONUT BREAD BAR	7.83	0.33
68	TAMALE BREAD BAR	6.95	0.45
69	APPLE CINNEMON DESSERT BAR	8.35	0.21
70	CHOCOLATE CHIP DESSERT BAR	8.16	0.15
71	CHOCOLATE HALVA DESSERT BAR	8.20	0.20
72	PECAN DESSERT BAR	8.12	0.26
73	GRAHAM DESSERT BAR	8.23	0.21
74	BLUEBERRY DESSERT BAR	8.18	0.30
75	FRUIT LEATHER	7.83	0.79
83	LEMON-LIME BEVERAGE BAR	6.06	0.66
39	COCOA BAR	7.93	0.10
40	STRAWBERRY BEVERAGE BAR	6.86	0.48
41	ORANGE BEVERAGE BAR	7.86	0.34
42	TROPICAL FRUIT BEVERAGE BAR	7.20	0.58
43	LEMONADE BEVERAGE BAR	7.00	0.70
84	RASPBERRY BEVERAGE BAR	6.60	0.60
85	TEA	8.29	0.15
86	COFFEE CUBE	7.90	0.12
87	TABASCO	8.65	0.12

RLW-30 DAY STUDY
R L W D A T A
OCTOBER, 1986

** WEEK 3 **
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
44	MIXED-NUT DAIRY BAR	8.21	0.12
45	BANANA DAIRY BAR	7.53	0.40
46	STRAWBERRY DAIRY BAR	7.94	0.24
47	ORANGE-PINEAPPLE-COCONUT BAR	8.09	0.16
48	VANILLA DAIRY BAR	7.64	0.32
49	ALMOND DAIRY BAR	7.94	0.19
50	CHICKEN ALA KING ENTREE BAR	7.75	0.37
51	PORK AND RICE ENTREE BAR	7.45	0.41
52	BEEF JERKY	7.67	0.19
53	CHILI ENTREE BAR	8.00	0.26
54	BEEF STEW ENTREE BAR	7.10	0.51
55	SPAGHETTI ENTREE BAR	7.67	0.33
56	CHICKEN AND RICE BAR	8.00	0.18
57	BRAN FLAKE CEREAL BAR	7.69	0.26
58	CORN FLAKE CEREAL BAR	7.75	0.31
59	WHEATIES CEREAL BAR	8.36	0.31
60	SHREDDED WHEAT BAR	7.44	0.23
61	LIFE CEREAL BAR	8.15	0.18
62	GRAPENUT CEREAL BAR	7.85	0.22
63	PIZZA BREAD BAR	7.25	0.40
64	ORANGE-NUT BREAD BAR	6.84	0.48
65	NACHO CHEESE BREAD BAR	6.65	0.48
66	BACON CHEESE BREAD BAR	7.04	0.43
67	COCONUT BREAD BAR	7.94	0.33
68	TAMALE BREAD BAR	7.11	0.48
69	APPLE CINNEMON DESSERT BAR	7.58	0.34
70	CHOCOLATE CHIP DESSERT BAR	7.86	0.38
71	CHOCOLATE HALVA DESSERT BAR	8.00	0.22
72	PECAN DESSERT BAR	8.17	0.26
73	GRAHAM DESSERT BAR	8.33	0.19
74	BLUEBERRY DESSERT BAR	7.69	0.31
75	FRUIT LEATHER	8.54	0.18
83	LEMON-LIME BEVERAGE BAR	6.95	0.50
39	COCOA BAR	7.24	0.14
40	STRAWBERRY BEVERAGE BAR	6.56	0.51
41	ORANGE BEVERAGE BAR	5.80	0.68
42	TROPICAL FRUIT BEVERAGE BAR	7.60	0.43
43	LEMONADE BEVERAGE BAR	5.82	0.88
84	RASPBERRY BEVERAGE BAR	6.27	0.67
85	TEA	8.32	0.13
86	COFFEE CUBE	7.91	0.13
87	TABASCO	8.75	0.08

RLW-30 DAY STUDY
R L W D A T A
OCTOBER, 1986

** WEEK 4 **
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
44	MIXED-NUT DAIRY BAR	7.54	0.23
45	BANANA DAIRY BAR	7.50	0.29
46	STRAWBERRY DAIRY BAR	7.68	0.25
47	ORANGE-PINEAPPLE-COCONUT BAR	7.50	0.26
48	VANILLA DAIRY BAR	7.88	0.37
49	ALMOND DAIRY BAR	7.56	0.25
50	CHICKEN ALA KING ENTREE BAR	7.63	0.23
51	PORK AND RICE ENTREE BAR	7.85	0.31
52	BEEF JERKY	7.41	0.14
53	CHILI ENTREE BAR	7.58	0.23
54	BEEF STEW ENTREE BAR	7.32	0.06
55	SPAGHETTI ENTREE BAR	7.35	0.27
56	CHICKEN AND RICE BAR	7.55	0.31
57	BRAN FLAKE CEREAL BAR	7.67	0.21
58	CORN FLAKE CEREAL BAR	7.56	0.28
59	WHEATIES CEREAL BAR	7.75	0.32
60	SHREDDED WHEAT BAR	7.70	0.28
61	LIFE CEREAL BAR	7.58	0.25
62	GRAPENUT CEREAL BAR	7.92	0.24
63	PIZZA BREAD BAR	7.18	0.41
64	ORANGE-NUT BREAD BAR	7.20	0.32
65	NACHO CHEESE BREAD BAR	6.75	0.40
66	BACON CHEESE BREAD BAR	6.84	0.34
67	COCONUT BREAD BAR	7.71	0.26
68	TAMALE BREAD BAR	6.38	0.29
69	APPLE CINNEMON DESSERT BAR	7.79	0.26
70	CHOCOLATE CHIP DESSERT BAR	7.88	0.27
71	CHOCOLATE HALVA DESSERT BAR	7.61	0.21
72	PECAN DESSERT BAR	7.77	0.26
73	GRAHAM DESSERT BAR	8.06	0.25
74	BLUEBERRY DESSERT BAR	7.40	0.24
75	FRUIT LEATHER	7.53	0.31
83	LEMON-LIME BEVERAGE BAR	6.28	0.49
39	COCOA BAR	7.66	0.24
40	STRAWBERRY BEVERAGE BAR	6.22	0.49
41	ORANGE BEVERAGE BAR	5.90	0.48
42	TROPICAL FRUIT BEVERAGE BAR	5.28	0.70
43	LEMONADE BEVERAGE BAR	6.23	0.71
84	RASPBERRY BEVERAGE BAR	6.59	0.40
85	TEA	7.91	0.13
86	COFFEE CUBE	7.89	0.12
87	TABASCO	8.22	0.15

APPENDIX 12
RLW-30 DAY STUDY, MRE ACCEPTANCE DATA

RLW-30 DAY STUDY
M R E D A T A
OCTOBER, 1986

WEEK 1
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
01	GRAVY BASE	7.20	0.92
02	CREAM SUBSTITUTE	7.71	0.20
03	CHEESE	6.63	0.24
04	PORK SAUSAGE PATTIES	6.29	0.47
05	HAM/CHICKEN LOAF	5.67	0.40
06	BEEF PATTIES	6.78	0.42
07	BEEF STEW	7.09	0.32
08	TURKEY W/GRAVY	6.85	0.21
09	HAM SLICES	6.94	0.43
10	BEEF W/SPICED SAUCE	6.48	0.25
11	MEATBALLS W/B.B-QUE SAUCE	6.65	0.26
12	BEEF W/GRAVY	7.15	0.40
13	FRANKFURTERS	6.72	0.39
14	BEEF W/B.B-QUE SAUCE	6.79	0.25
15	BEANS W/TOMATO SAUCE	7.13	0.22
16	PEANUT BUTTER	7.02	0.17
17	CRACKERS	6.84	0.14
18	CHERRY NUT CAKE	6.59	0.44
19	MAPLE NUT CAKE	7.27	0.33
20	FRUITCAKE	5.92	0.50
21	ORANGE NUT CAKE	5.67	0.65
22	BROWNIE	7.28	0.31
23	CHOCOLATE COVERED COOKIE	7.12	0.25
24	APPLESAUCE	7.79	0.37
25	MIXED FRUITS	7.00	0.29
26	PEACHES	7.00	0.33
27	STRAWBERRIES	8.00	0.29
28	CATSUP	6.60	1.12
29	COCOA POWDER	7.69	0.16
30	PEARS	8.00	------
31	JELLY	7.35	0.18
37	COFFEE	7.70	0.17
38	SUGAR	7.89	0.20
76	CHICKEN ALA KING	6.60	0.25
77	BEVERAGE POWDER	8.01	0.14
78	POTATO PATTY	6.39	0.31
79	SALT	5.71	0.36
80	PINEAPPLE NUT	5.62	0.46
81	CHOCOLATE NUT CAKE	7.53	0.32
82	GUM	7.81	0.18

RLW-30 DAY STUDY
M R E D A T A
OCTOBER, 1986

WEEK 2
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
01	GRAVY BASE	6.63	0.53
02	CREAM SUBSTITUTE	7.67	0.17
03	CHEESE	7.48	0.21
04	PORK SAUSAGE PATTIES	7.06	0.46
05	HAM/CHICKEN LOAF	5.18	0.92
06	BEEF PATTIES	6.93	0.47
07	BEEF STEW	7.57	0.32
08	TURKEY W/GRAVY	7.05	0.38
09	HAM SLICES	7.26	0.35
10	BEEF W/SPICED SAUCE	6.70	0.21
11	MEATBALLSW/B.B-QUE SAUCE	6.70	0.28
12	BEEF W/GRAVY	7.00	0.39
13	FRANKFURTERS	7.46	0.27
14	BEEF W/B.B-QUE SAUCE	7.26	0.28
15	BEANS W/TOMATO SAUCE	7.38	0.20
16	PEANUT BUTTER	7.14	0.15
17	CRACKERS	6.86	0.13
18	CHERRY NUT CAKE	7.25	0.45
19	MAPLE NUT CAKE	7.79	0.42
20	FRUITCAKE	6.30	0.52
21	ORANGE NUT CAKE	5.56	0.29
22	BROWNIE	7.76	0.22
23	CHOCOLATE COVERED COOKIE	7.60	0.17
24	APPLESAUCE	8.12	0.20
25	MIXED FRUITS	7.45	0.23
26	PEACHES	7.52	0.29
27	STRAWBERRIES	7.85	0.31
28	CATSUP	6.44	0.53
29	COCOA POWDER	7.86	0.14
30	PEARS	------	------
31	JELLY	7.29	0.24
37	COFFEE	7.67	0.17
38	SUGAR	7.97	0.17
76	CHICKEN ALA KING	7.00	0.25
77	BEVERAGE POWDER	7.98	0.18
78	POTATO PATTY	6.81	0.34
79	SALT	7.83	0.54
80	PINEAPPLE NUT	6.50	0.37
81	CHOCOLATE NUT CAKE	7.68	0.32
82	GUM	7.16	0.20

RLW-30 DAY STUDY
M R E D A T A
OCTOBER, 1986

WEEK 3
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
01	GRAVY BASE	7.00	0.41
02	CREAM SUBSTITUTE	7.79	0.19
03	CHEESE	7.27	0.24
04	PORK SAUSAGE PATTIES	6.67	0.35
05	HAM/CHICKEN LOAF	5.75	0.71
06	BEEF PATTIES	7.53	0.35
07	BEEF STEW	7.38	0.31
08	TURKEY W/GRAVY	7.33	0.33
09	HAM SLICES	7.57	0.34
10	BEEF W/SPICED SAUCE	7.48	0.22
11	MEATBALLSW/B.B-QUE SAUCE	7.09	0.28
12	BEEF W/GRAVY	7.52	0.34
13	FRANKFURTERS	7.43	0.44
14	BEEF W/B.B-QUE SAUCE	7.65	0.26
15	BEANS W/TOMATO SAUCE	7.39	0.19
16	PEANUT BUTTER	7.33	0.20
17	CRACKERS	6.98	0.15
18	CHERRY NUT CAKE	7.46	0.46
19	MAPLE NUT CAKE	7.00	0.37
20	FRUITCAKE	5.38	0.60
21	ORANGE NUT CAKE	5.29	0.52
22	BROWNIE	7.94	0.25
23	CHOCOLATE COVERED COOKIE	7.57	0.21
24	APPLESAUCE	7.92	0.26
25	MIXED FRUITS	7.77	0.32
26	PEACHES	7.59	0.27
27	STRAWBERRIES	7.68	0.31
28	CATSUP	7.47	0.42
29	COCOA POWDER	8.17	0.16
30	PEARS	-------	-------
31	JELLY	7.55	0.21
37	COFFEE	7.83	0.18
38	SUGAR	8.13	0.16
76	CHICKEN ALA KING	6.84	0.27
77	BEVERAGE POWDER	7.53	0.22
78	POTATO PATTY	7.00	0.25
79	SALT	7.25	0.58
80	PINEAPPLE NUT	6.44	0.68
81	CHOCOLATE NUT CAKE	7.11	0.50
82	GUM	7.59	0.21

RLW-30 DAY STUDY
M R E D A T A
OCTOBER, 1986

WEEK 4
ACCEPTANCE

ITEM #	ITEM NAME	MEAN	STANDARD ERROR
01	GRAVY BASE	7.57	0.43
02	CREAM SUBSTITUTE	7.56	0.17
03	CHEESE	7.20	0.18
04	PORK SAUSAGE PATTIES	6.57	0.36
05	HAM/CHICKEN LOAF	6.33	0.24
06	BEEF PATTIES	7.41	0.29
07	BEEF STEW	7.18	0.25
08	TURKEY W/GRAVY	7.10	0.34
09	HAM SLICES	6.82	0.38
10	BEEF W/SPICED SAUCE	7.20	0.23
11	MEATBALLS W/B.B-QUE SAUCE	7.00	0.38
12	BEEF W/GRAVY	7.14	0.26
13	FRANKFURTERS	6.77	0.29
14	BEEF W/B.B-QUE SAUCE	7.51	0.28
15	BEANS W/TOMATO SAUCE	7.30	0.17
16	PEANUT BUTTER	7.19	0.19
17	CRACKERS	6.89	0.13
18	CHERRY NUT CAKE	7.41	0.41
19	MAPLE NUT CAKE	7.68	0.34
20	FRUITCAKE	6.36	0.34
21	ORANGE NUT CAKE	5.36	0.82
22	BROWNIE	7.48	0.28
23	CHOCOLATE COVERED COOKIE	7.14	0.21
24	APPLESAUCE	9.00	0.12
25	MIXED FRUITS	7.52	0.21
26	PEACHES	6.92	0.35
27	STRAWBERRIES	7.47	0.28
28	CATSUP	7.10	0.55
29	COCOA POWDER	7.64	0.16
30	PEARS	------	------
31	JELLY	7.55	0.18
37	COFFEE	7.46	0.19
38	SUGAR	7.72	0.17
76	CHICKEN ALA KING	7.07	0.33
77	BEVERAGE POWDER	7.56	0.19
78	POTATO PATTY	6.98	0.24
79	SALT	7.46	0.43
80	PINEAPPLE NUT	6.40	0.44
81	CHOCOLATE NUT CAKE	7.13	0.39
82	GUM	7.29	0.22

DISTRIBUTION LIST

	NO. OF COPIES
Defense Technical Information Center ATTN: DTIC-DDA Alexandria, VA 22304-6145	12
Commander U.S. Army Medical Research and Development Command SGRD-RMS SGRD-PLC Fort Detrick Fredrick, MD 21701-5012	2 1
Commandant Academy of Health Sciences, U.S. Army ATTN: AHS-CDM Fort Sam Houston, TX 78234	1
Dir of Biol & Med Sciences Division Office of Naval Research 800 N. Quincy Street Arlington, VA 22217	1
CO, Naval Medical R&D Command National Naval Medical Center Bethesda, MD 20014	1
HQ AFMSC/SGPA Brooks AFB, TX 78235	1
Under Secretary of Defense Research and Engineering ATTN: OUSDRE(RAT)E&LS Washington, DC 20310	1
Dean School of Medicine Uniformed Services University of Health Sciences 4301 Jones Bridge Road Bethesda, MD 20014	1
Commander U.S. Army War College Carlisle Barracks, PA 17013	1
Commander U.S. Army Soldier Support Center Ft. Benjamin Harrison, IN 46216	1

Assistant Secretary of Defense (Health Affairs) 1
ATTN: ASD(HA) PA&QA
Washington, DC 20310

Assistant Secretary of Defense (Aquisition & Logistics) 1
ATTN: OASD(A&L)SD
Washington, DC 20310

Commander 1
U.S. Army Troop Support Command
ATTN: AMSTR-E
4300 Goodfellow Boulevard
St. Louis, MO 63120-1798

Commander 1
U.S. Army Test and Evaluation Command
ATTN: AMSTE-EV-S
Aberdeen Proving Ground, MD 21005-5055

Commander 1
U.S. Army Operational Test Evaluation Agency
ATTN: CSTE-ZX
5600 Columbia Pike
Falls Church, VA 22041

Commander U.S. Army Training and Doctrine Command 1
ATTN: ATCD-S
Fort Monroe, VA 23651

Commander 1
U.S. Army TRADOC Combined Arms Test Activity
ATTN: ATCT-PO
Ft. Hood, TX 76544

Commander 1
U.S. Army Materiel Command
ATTN: AMCDE-S
Alexandria, VA 22333

Commander 1
U.S. Army Combined Arms Center
ATTN: ATZL-TIE
Fort Leavenworth, KS 66027-5130

HQDA 1
OTSG
ATTN: DASG-DBD
Rm 617, Bldg 5
Skyline Place
5111 Leesburg Pike, VA 22041-3258

HQDA 1
ATTN: DASG-RDZ
Washington, DC 20310-2300

HQDA 1
DCSLOG
ATTN: DALO-TST
Washington, DC 20310-2300

Commandant
U.S. Army Quartermaster School
ATTN: ATSM-CDT 1
ATTN: ATSM-SFS 1
Fort Lee, VA 23807

Commandant
U.S. Army Troop Support Agency
ATTN: DALO-TAF 1
ATTN: DALO-TAF-F
FT. Lee, VA 23801

Commander
U.S. Army Natick Research, Development and
Engineering Center
ATTN: STRNC-W 1
ATTN: STRNC-Y 1
ATTN: STRNC-T 1
ATTN: STRNC-E 1
Natick, MA 01760-5000

Commander
John F. Kennedy Special Warfare Center
ATTN: ATSU-CD-TE 1
ATTN: ATSU-CD-ML-M 1
ATTN: DOCD-M-L 1
Fort Bragg, NC 28307-5000

Commander 1
10th SFG (A)
Ft. Devens, MA 01433

Commander 1
3rd BN/10th SFG (A)
Ft. Devens, MA 01433

Surgeon (AFVS-SFC-SU) 1
10th SFG (A)
Ft. Devens, MA 01433

U. S. GOVERNMENT PRINTING OFFICE: 1987--700-018--30,502